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Johnson et al.

(10) **Patent No.:** **US 9,326,094 B2**
(45) **Date of Patent:** **Apr. 26, 2016**

(54) **BLE/WIFI BRIDGE WITH AUDIO SENSOR**

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(73) Assignee: **August Home, Inc.**, San Francisco, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 56 days.

(21) Appl. No.: **14/461,177**

(22) Filed: **Aug. 15, 2014**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation-in-part of application No. 14/212,569, filed on Mar. 14, 2014.

(60) Provisional application No. 61/800,937, filed on Mar. 15, 2013, provisional application No. 61/801,236,

(Continued)

(51) **Int. Cl.**

G08B 1/08 (2006.01)

H04W 4/00 (2009.01)

G08B 25/00 (2006.01)

(Continued)

(52) **U.S. Cl.**

CPC **H04W 4/008** (2013.01); **E05B 47/026** (2013.01); **G08B 1/08** (2013.01); **G08B 25/009** (2013.01); **E05B 45/06** (2013.01); **E05B 47/0012** (2013.01); **E05B 2047/0058** (2013.01); **E05B 2047/0067** (2013.01); **E05B 2047/0084**

(2013.01); **E05B 2047/0091** (2013.01); **E05B 2047/0094** (2013.01); **H04W 84/12** (2013.01)

(58) **Field of Classification Search**

CPC **G08B 29/18**; **H04W 80/04**
USPC **340/539.14**, **539.12**, **5.51**, **5.58**, **540**, **340/541**

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,680,177 A 6/1954 Rosenthal
5,306,407 A 4/1994 Hauzer et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CA 2676196 A1 7/2008
EP 0486657 A1 5/1992

(Continued)

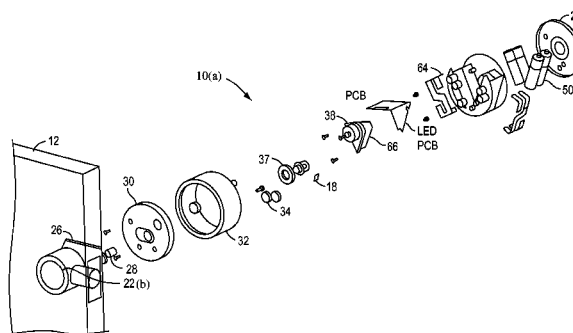
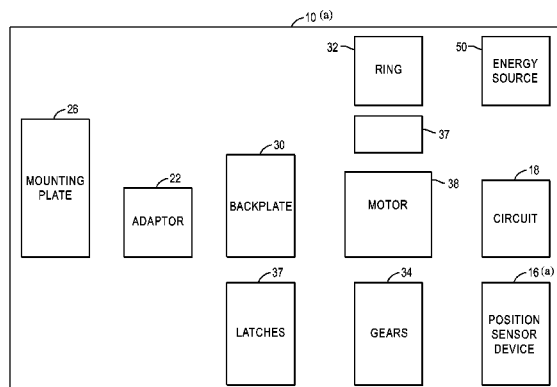
Primary Examiner — Tai T Nguyen

(74) *Attorney, Agent, or Firm* — Beyer Law Group LLP

(57) **ABSTRACT**

A Bluetooth/WiFi bridge includes a computing device in an interior of a dwelling with an internet-facing radio, and a second radio communicating with one or more non-internet-connected devices. The computing device provides for coordination of information flow between the two radios. The computing device is configured to enable the two radios to communicate and take incoming and outgoing information from one radio into a format that the other radio can transmit and receive. An audio sensor is configured to receive a sound from the one or more non-internet connected devices. The audio sensor being coupled to a logic circuit in the computing device. The internet facing radio is configured to communicate through a router to the internet and the non-internet devices connect to the internet via one of the radios through the computing device through the internet facing radio through the router to the internet, with the bridge communicating with a data center.

35 Claims, 48 Drawing Sheets



Related U.S. Application Data

filed on Mar. 15, 2013, provisional application No. 61/801,294, filed on Mar. 15, 2013, provisional application No. 61/801,335, filed on Mar. 15, 2013, provisional application No. 62/036,993, filed on Aug. 13, 2014, provisional application No. 62/036,991, filed on Aug. 13, 2014, provisional application No. 62/036,989, filed on Aug. 13, 2014, provisional application No. 62/036,971, filed on Aug. 13, 2014, provisional application No. 62/036,979, filed on Aug. 13, 2014.

(51) **Int. Cl.**

E05B 47/02 (2006.01)
H04W 84/12 (2009.01)
E05B 45/06 (2006.01)
E05B 47/00 (2006.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,407,035 A 4/1995 Cole et al.
 5,695,048 A 12/1997 Tseng
 6,196,936 B1 3/2001 Meckel
 6,323,846 B1 11/2001 Westerman et al.
 6,570,557 B1 5/2003 Westerman et al.
 6,612,415 B2 9/2003 Yamane
 6,677,932 B1 1/2004 Westerman
 7,614,008 B2 11/2009 Ording
 7,633,076 B2 12/2009 Huppi et al.
 7,653,883 B2 1/2010 Hotelling et al.
 7,657,849 B2 2/2010 Chaudhri et al.
 7,663,607 B2 2/2010 Hotelling et al.
 7,844,914 B2 11/2010 Andre et al.

8,006,002 B2 8/2011 Kalayjian et al.
 8,239,784 B2 8/2012 Hotelling et al.
 8,279,180 B2 10/2012 Hotelling et al.
 8,347,720 B2 1/2013 De Los Santos et al.
 8,351,789 B2 1/2013 Wagener et al.
 8,405,387 B2 3/2013 Novak et al.
 8,476,577 B2 7/2013 Nagahama et al.
 8,479,122 B2 7/2013 Hotelling et al.
 8,522,596 B2 9/2013 Avery
 8,525,102 B2 9/2013 Augustyniak et al.
 8,542,189 B2 9/2013 Milne et al.
 8,544,326 B2 10/2013 Je
 8,600,430 B2 12/2013 Herz et al.
 2002/0015024 A1 2/2002 Westerman et al.
 2005/0252739 A1 11/2005 Callahan et al.
 2006/0026536 A1 2/2006 Hotelling et al.
 2006/0033724 A1 2/2006 Chaudhri et al.
 2006/0197753 A1 9/2006 Hotelling
 2007/0150842 A1 6/2007 Chaudhri et al.
 2012/0319827 A1 12/2012 Pance et al.
 2013/0063138 A1 3/2013 Takahashi et al.
 2013/0064378 A1 3/2013 Chuang
 2014/0052783 A1* 2/2014 Swatsky H04W 80/04
 709/204
 2014/0189758 A1* 7/2014 Kozlowski H04N 21/43637
 725/81

FOREIGN PATENT DOCUMENTS

EP 0907068 A1 4/1999
 EP 1404021 A2 3/2004
 EP 2428774 A1 3/2012
 EP 2454558 A1 5/2012
 EP 2564165 A2 3/2013
 EP 2579002 A1 4/2013
 EP 2642252 A1 9/2013

* cited by examiner

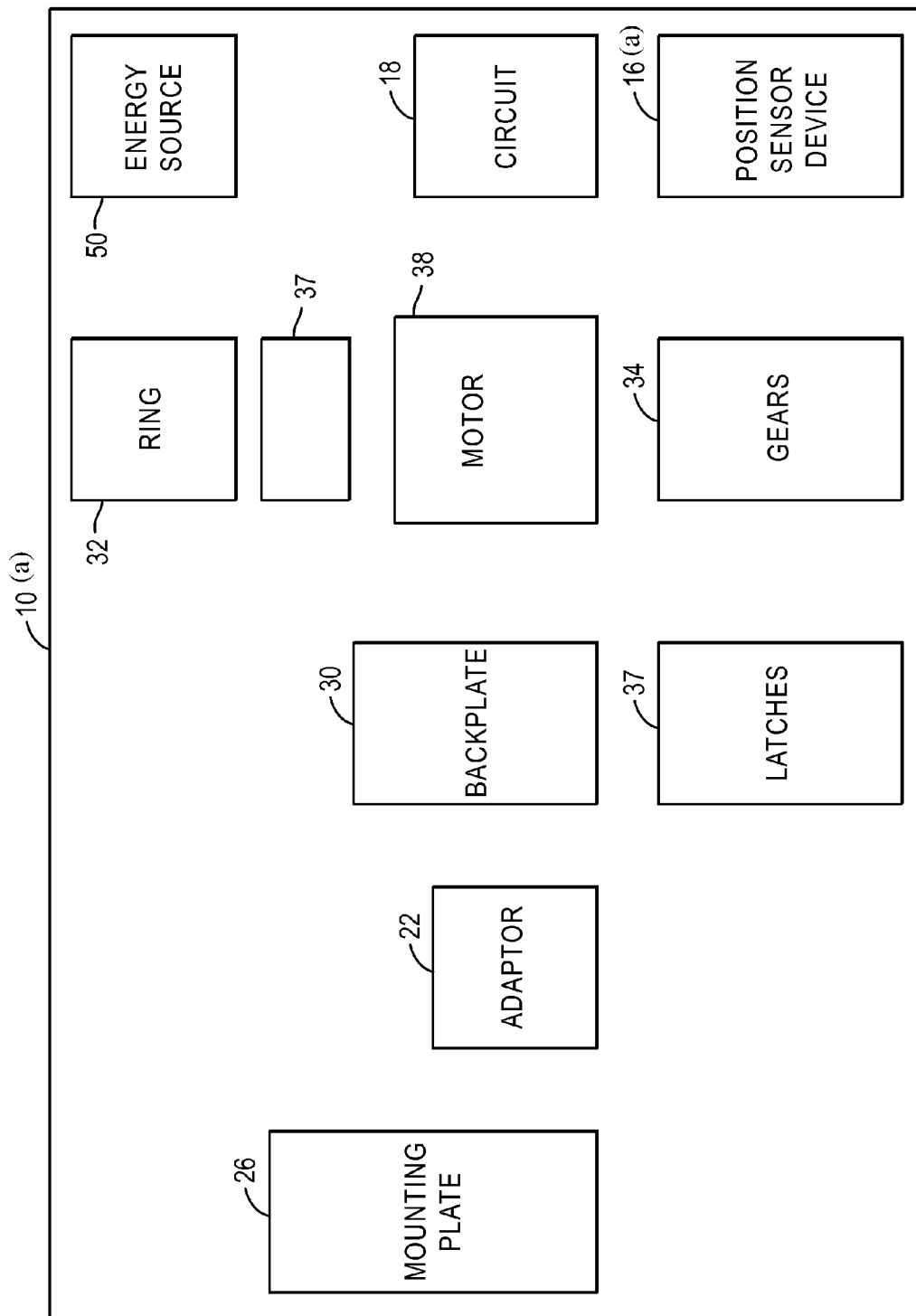
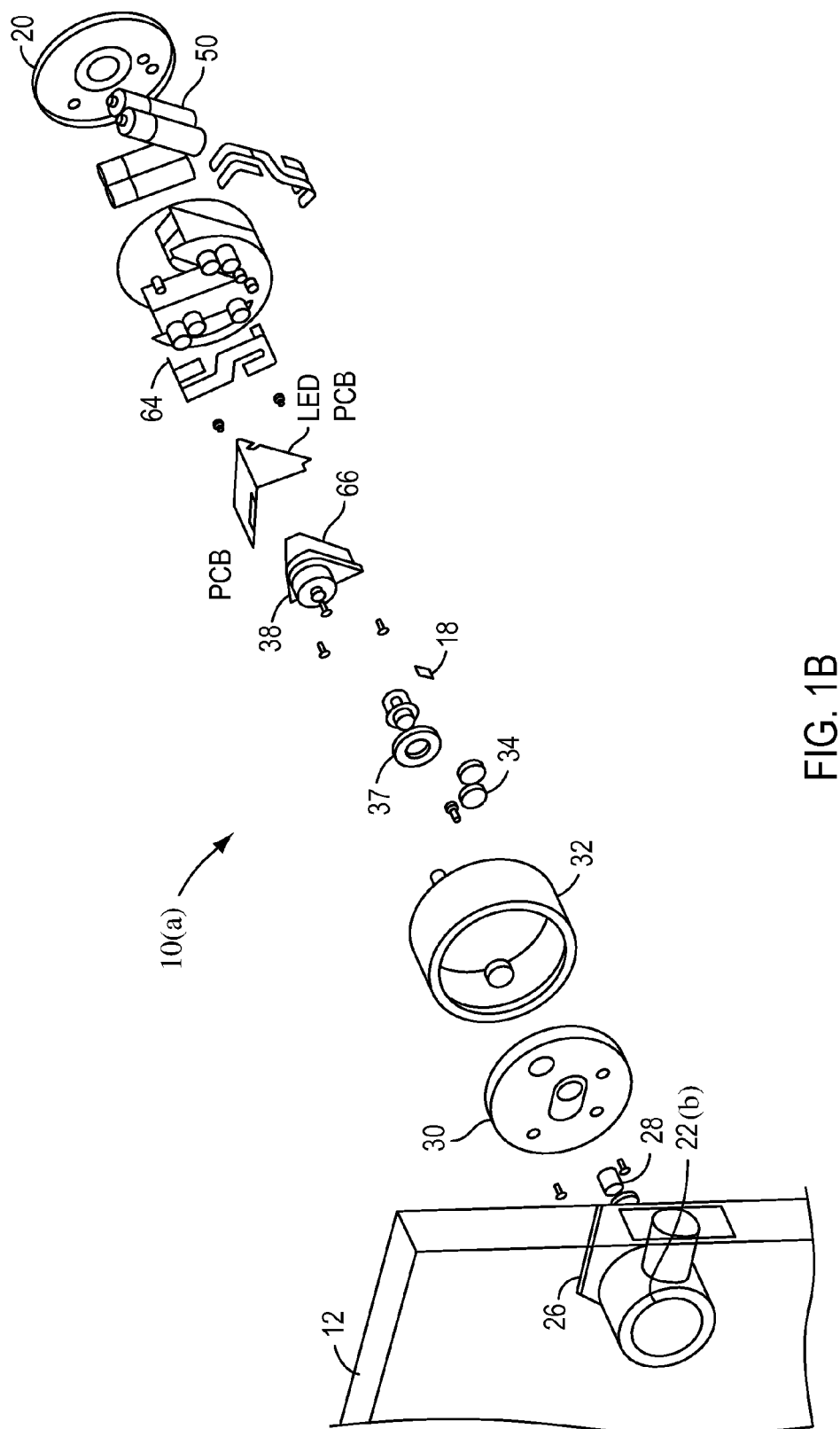


FIG. 1A



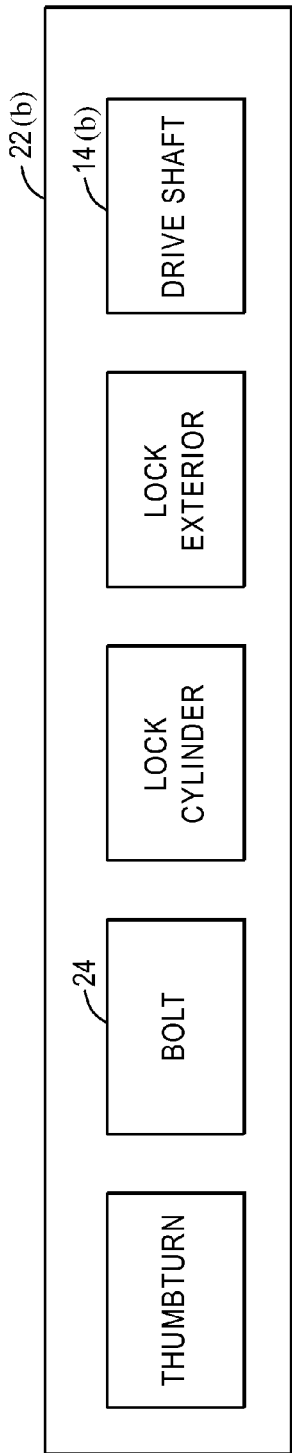


FIG. 1C

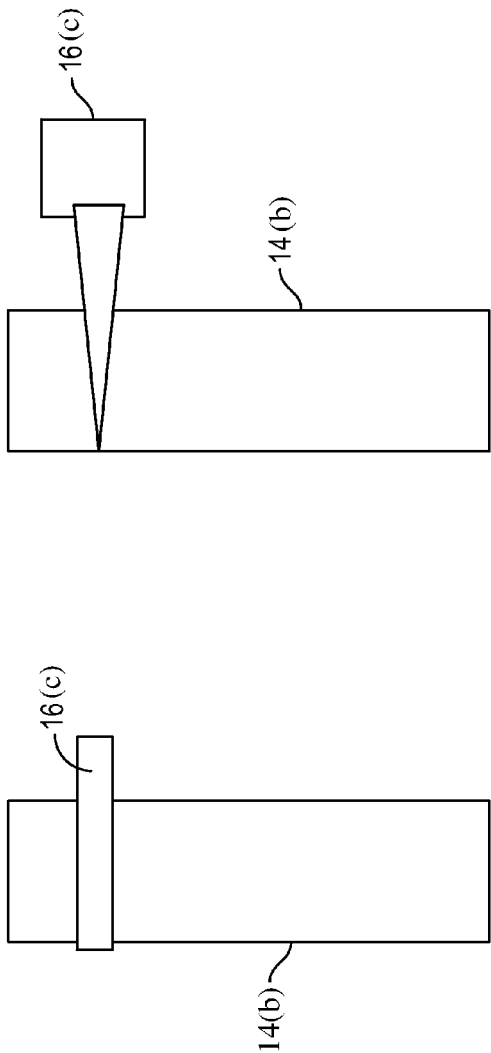


FIG. 1D

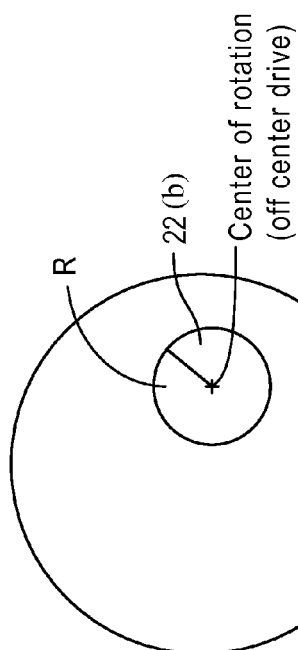


FIG. 1E

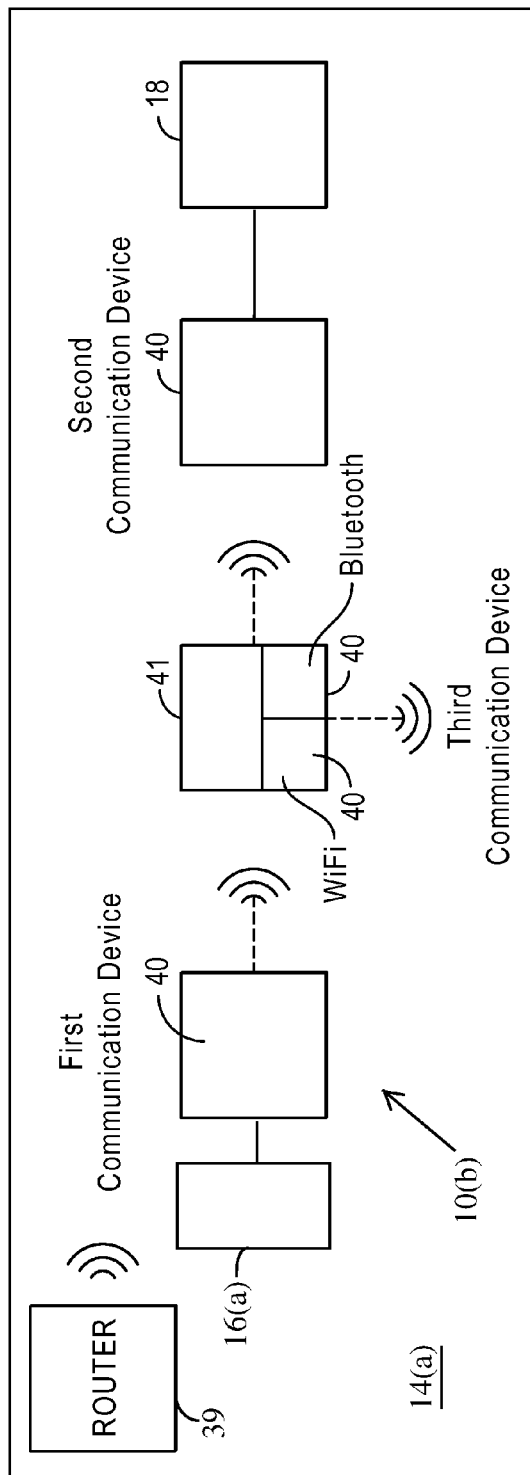


FIG. 1F

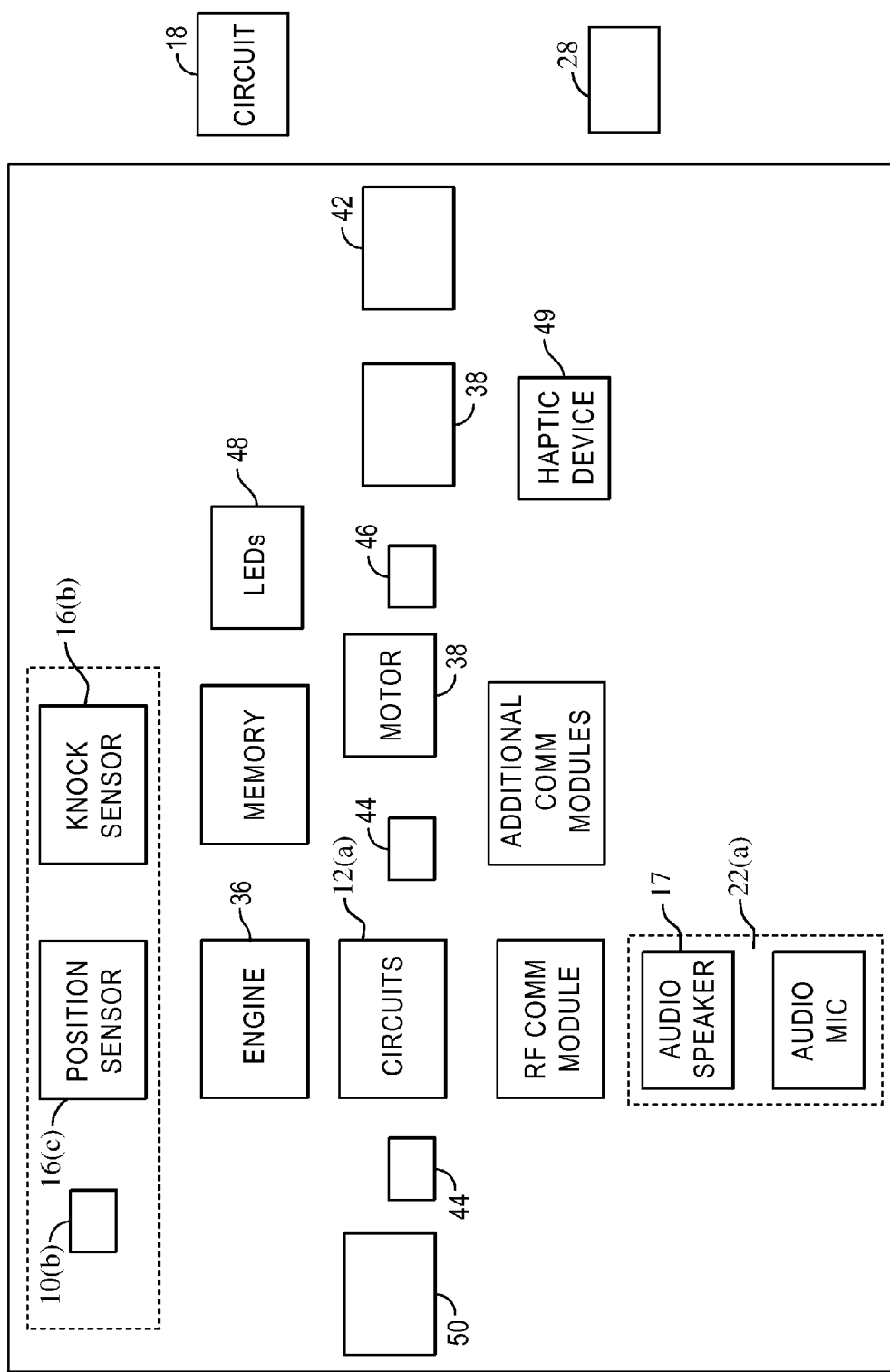


FIG. 1G

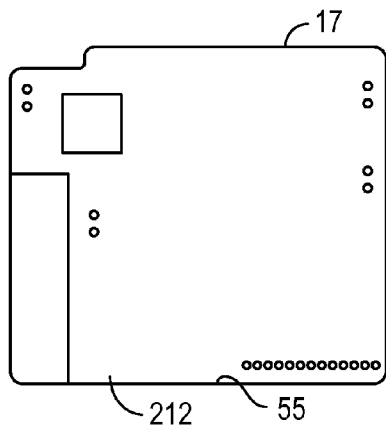


FIG. 2A

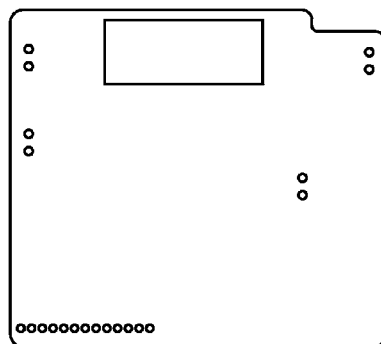


FIG. 2B

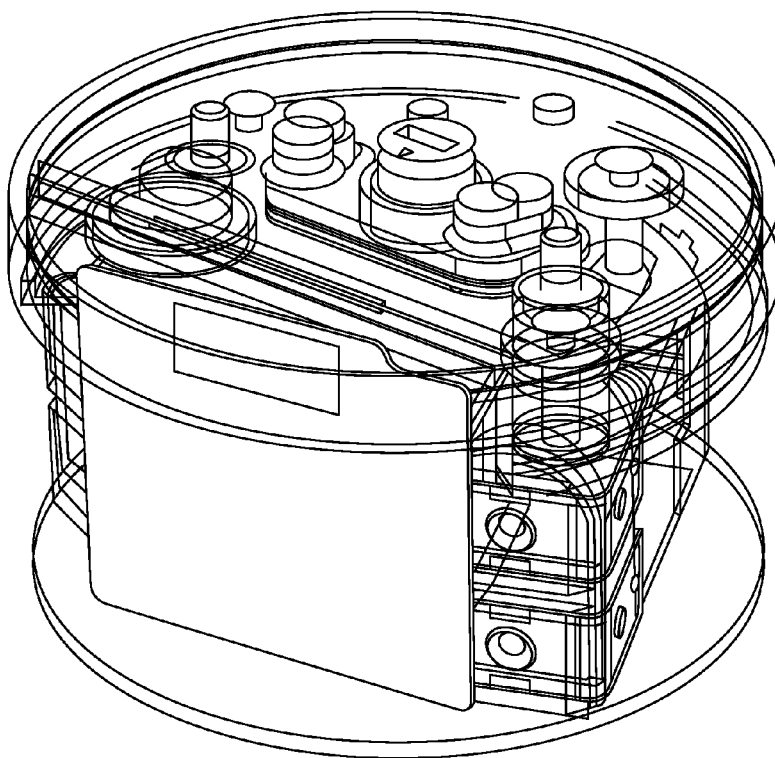


FIG. 2C

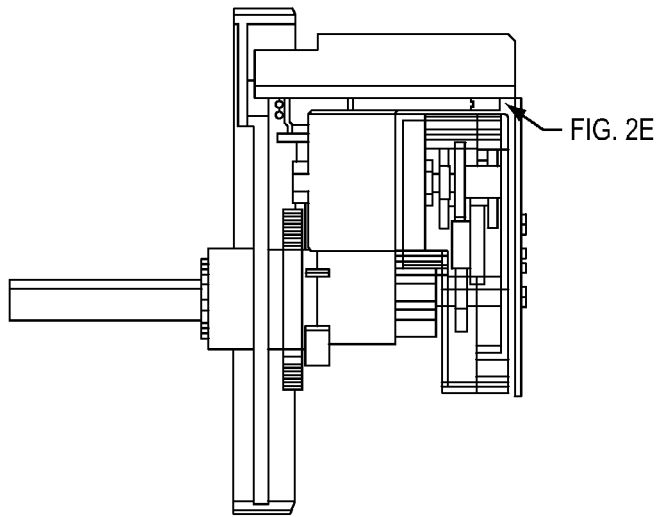


FIG. 2D

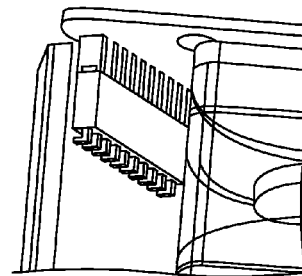


FIG. 2E

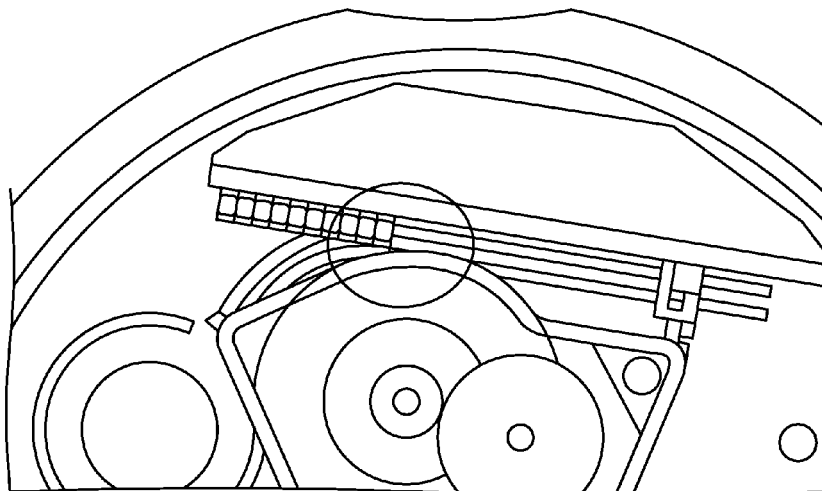


FIG. 2F

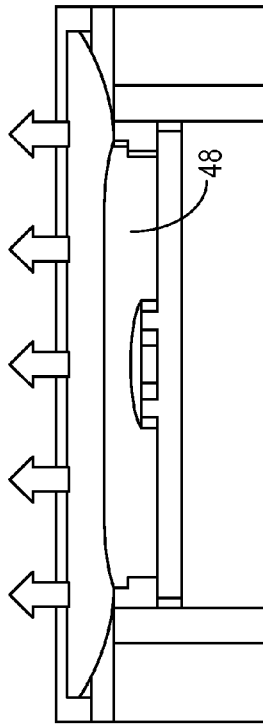


FIG. 3B

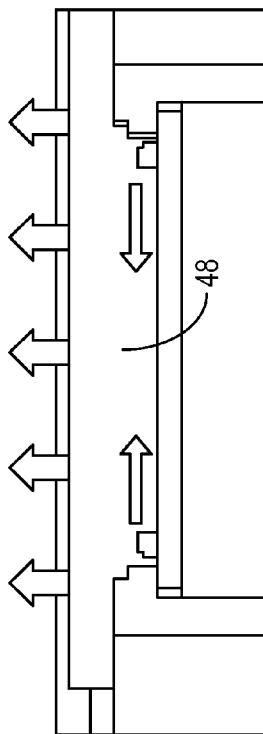


FIG. 3A

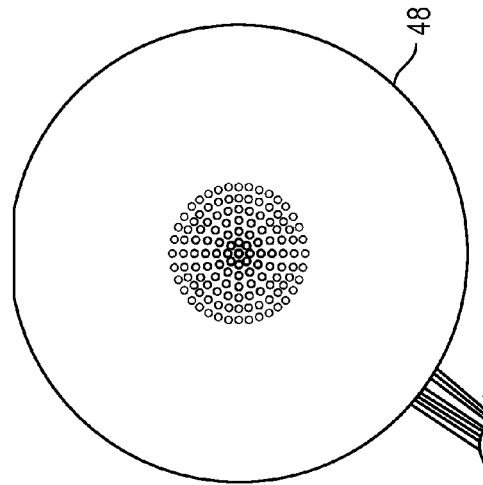


FIG. 3D

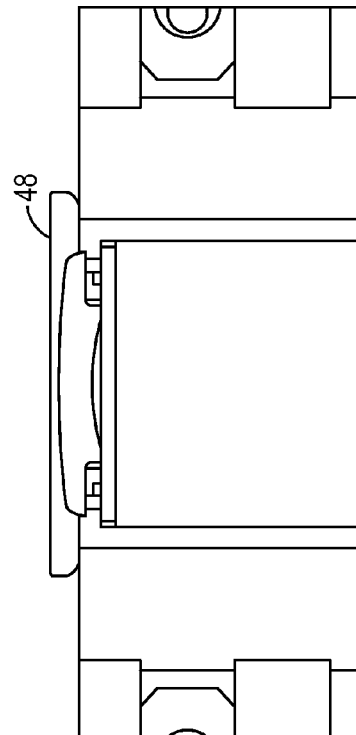


FIG. 3C

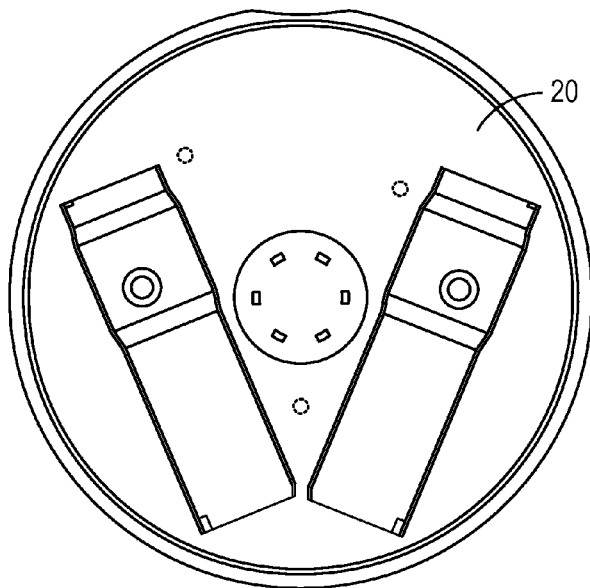


FIG. 4A

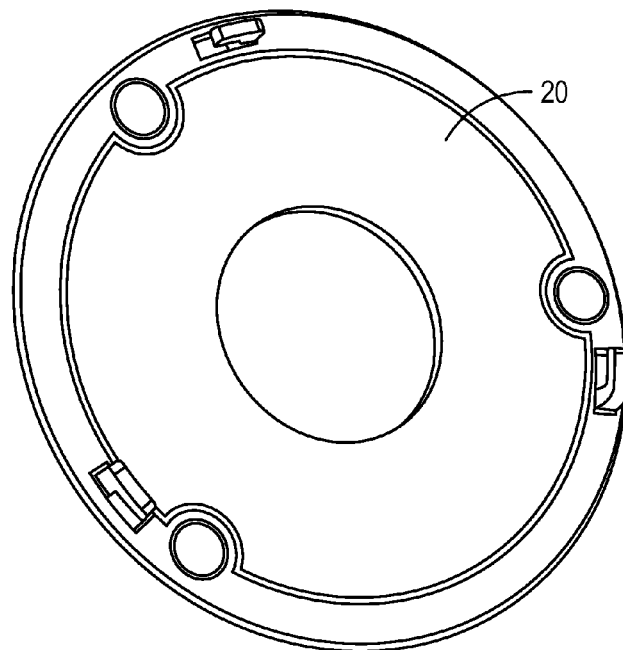


FIG. 4B

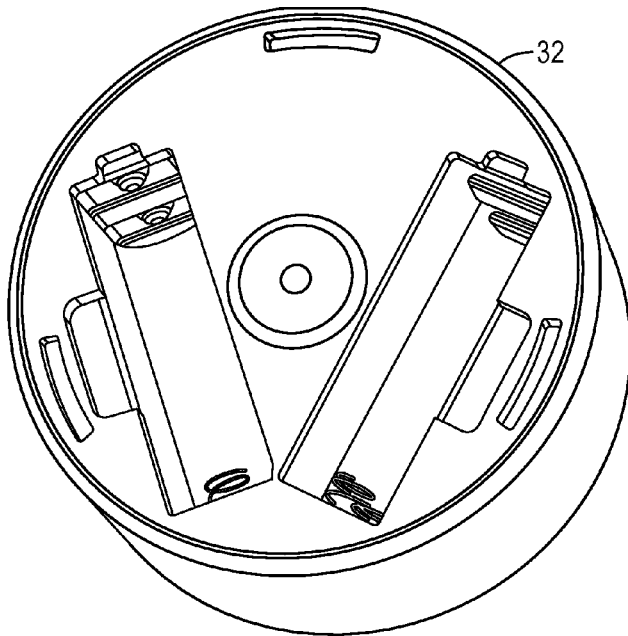


FIG. 4C

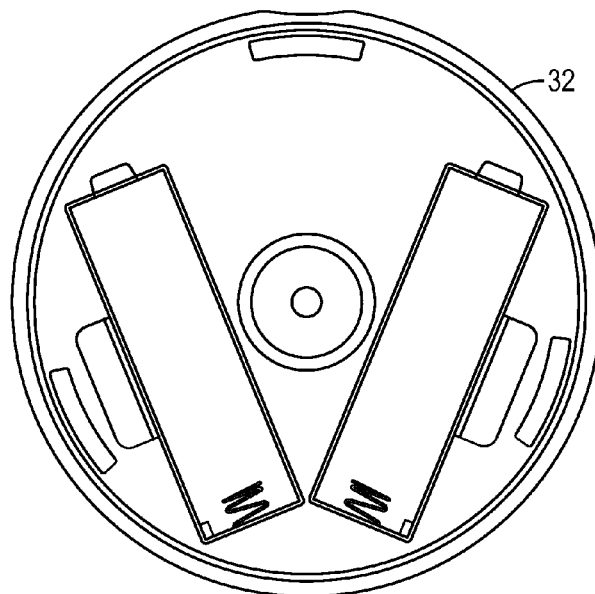


FIG. 4D

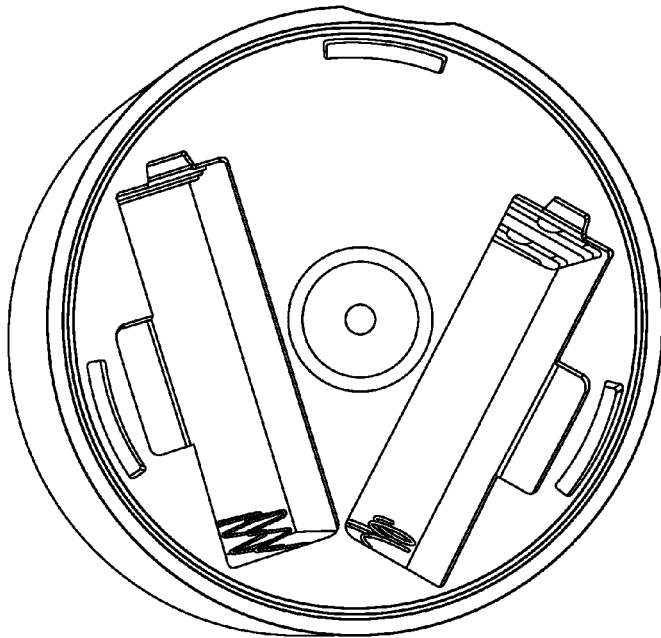


FIG. 5A

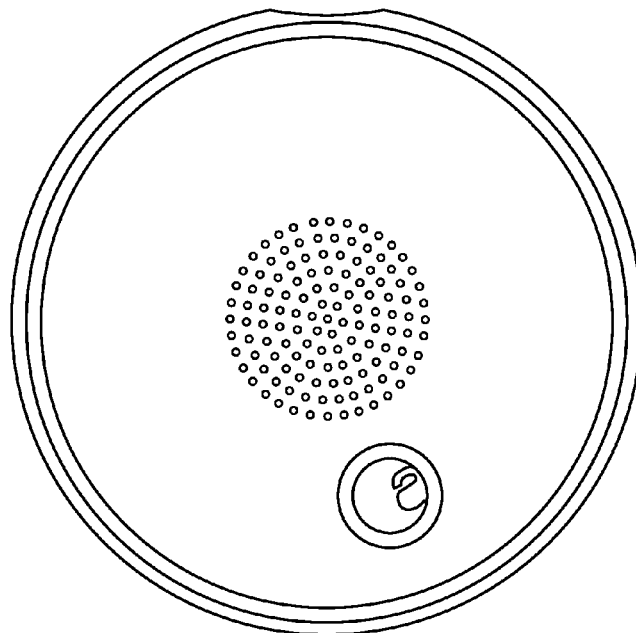


FIG. 5B

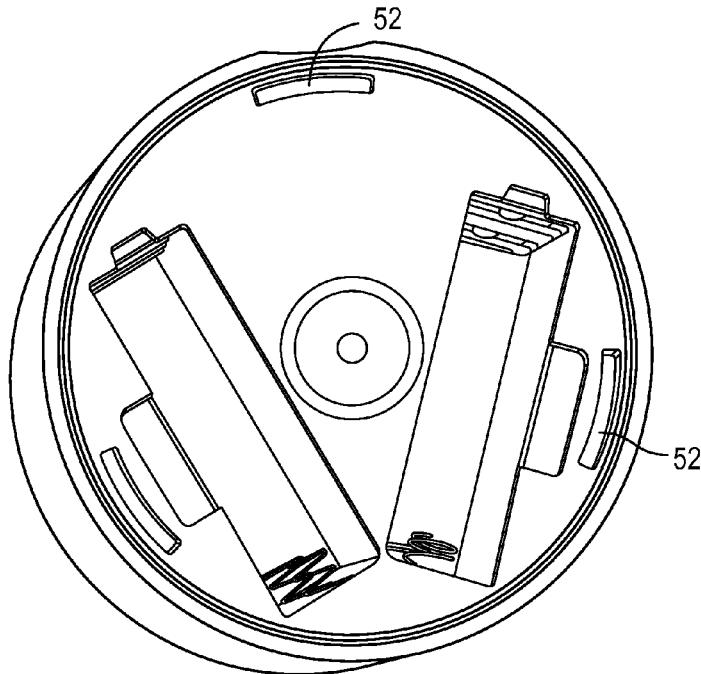


FIG. 6A

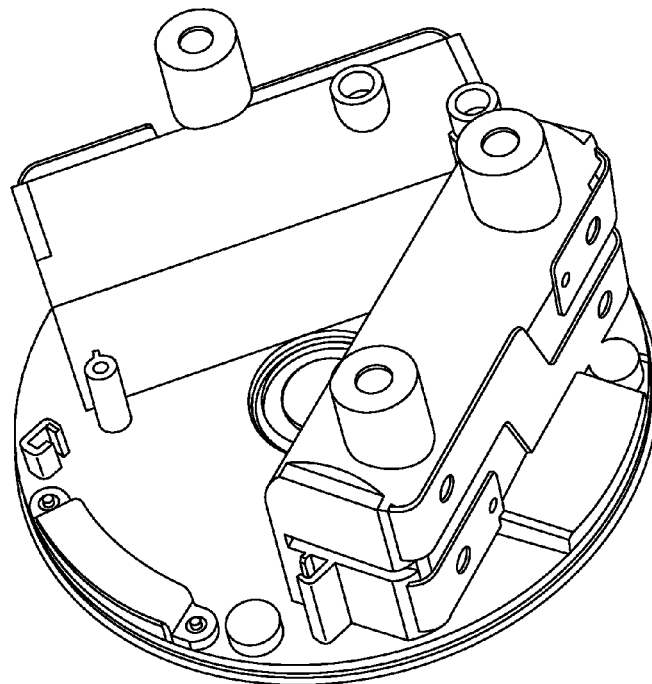


FIG. 6B

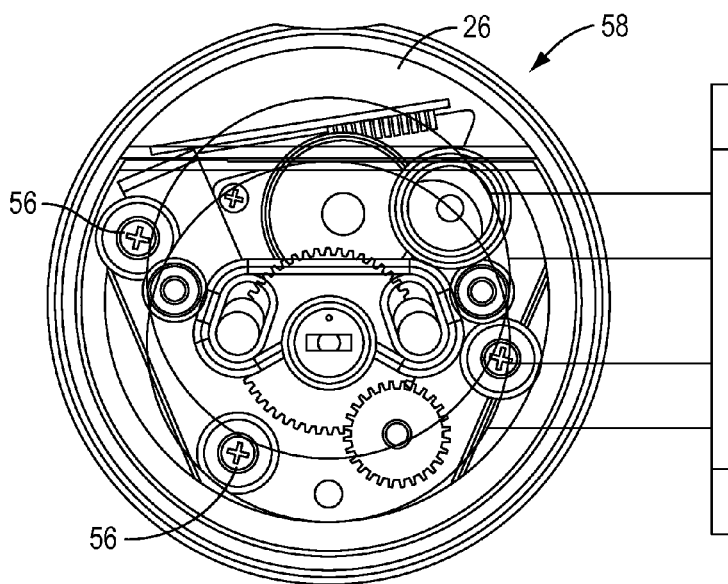


FIG. 7A

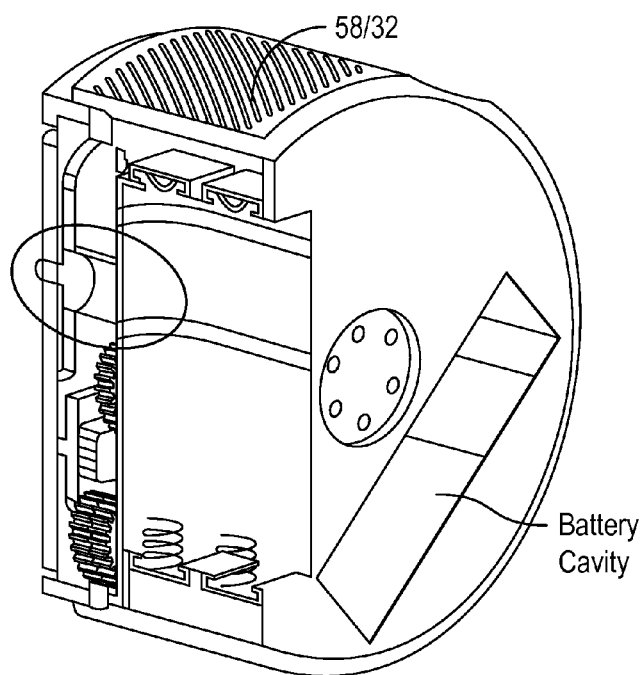


FIG. 7B

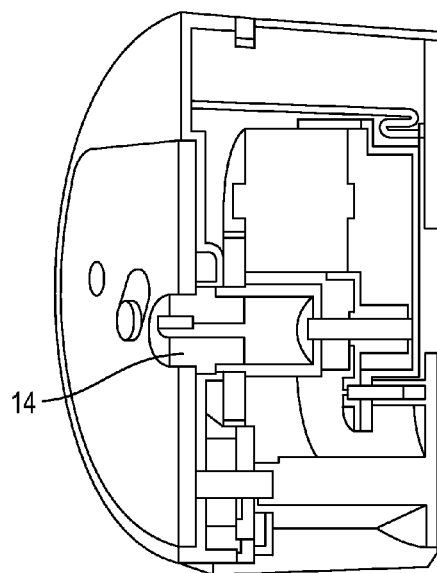


FIG. 7C

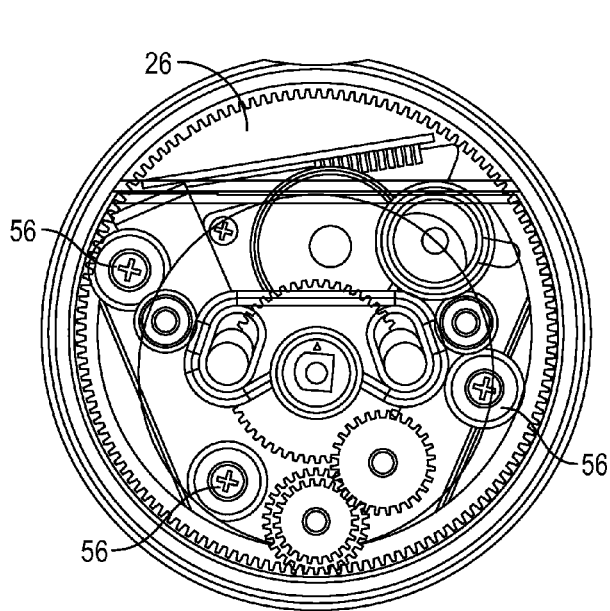


FIG. 7D

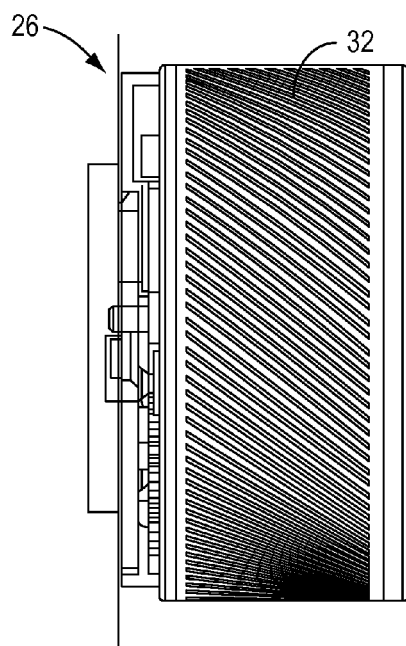


FIG. 7E

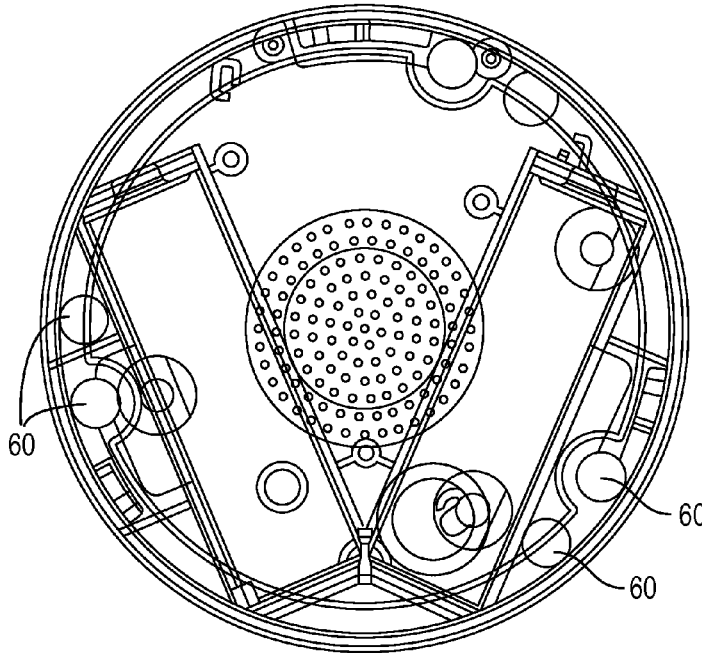


FIG. 8A

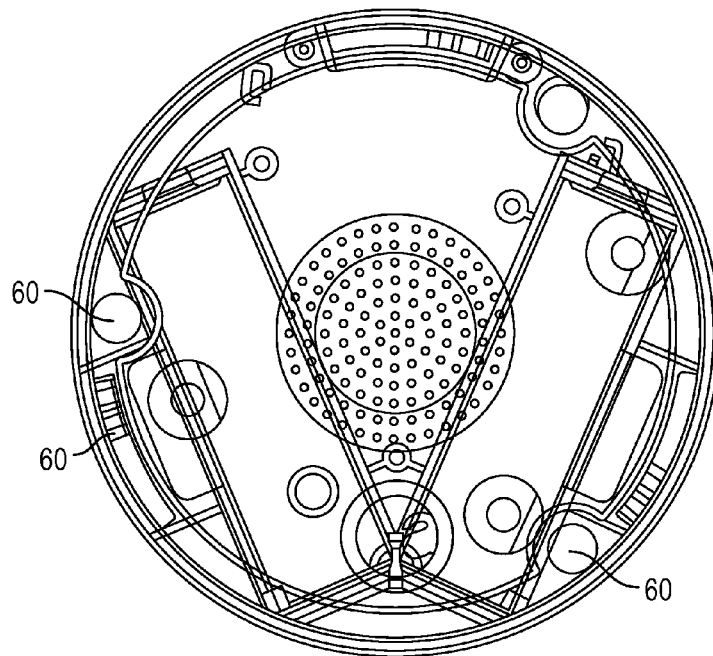


FIG. 8B

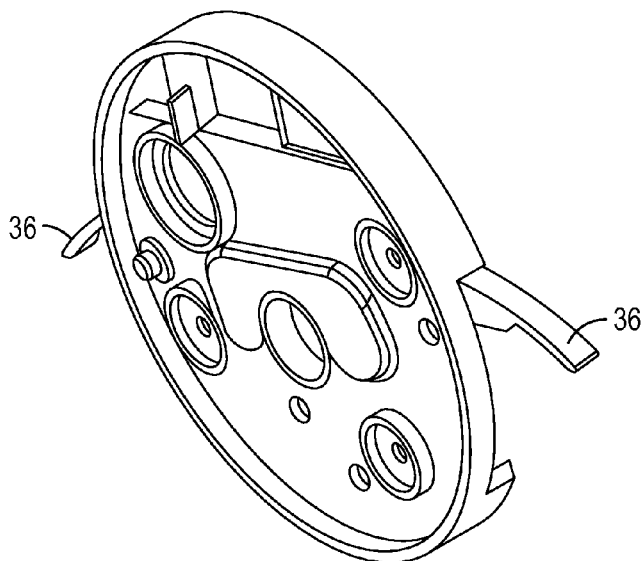


FIG. 9A

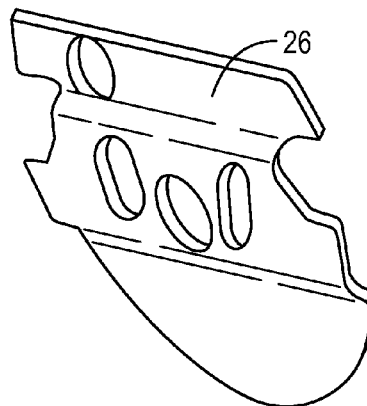


FIG. 9B

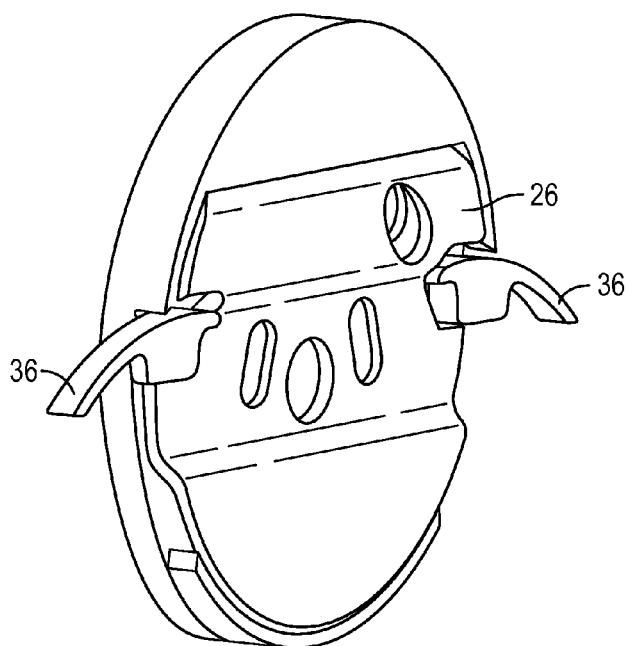


FIG. 9C

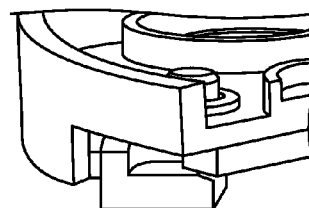


FIG. 9E

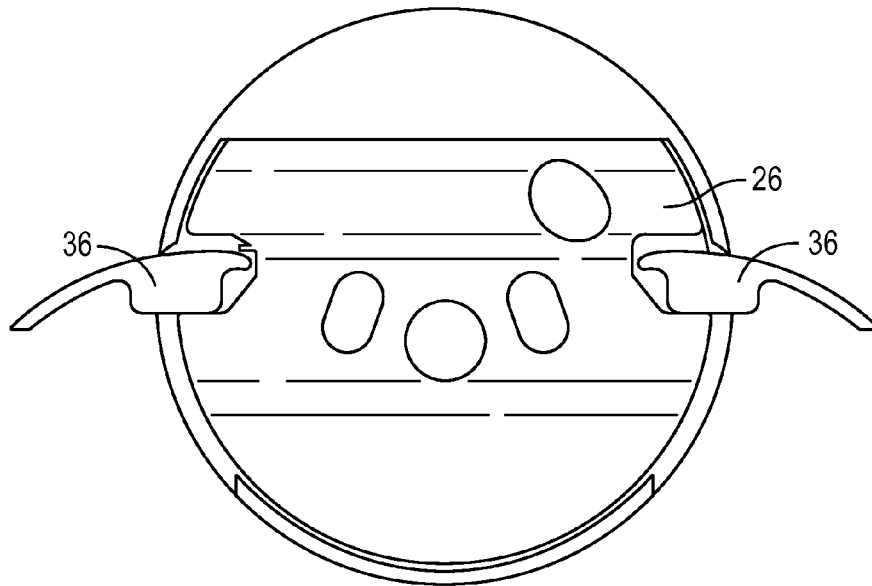


FIG. 9D

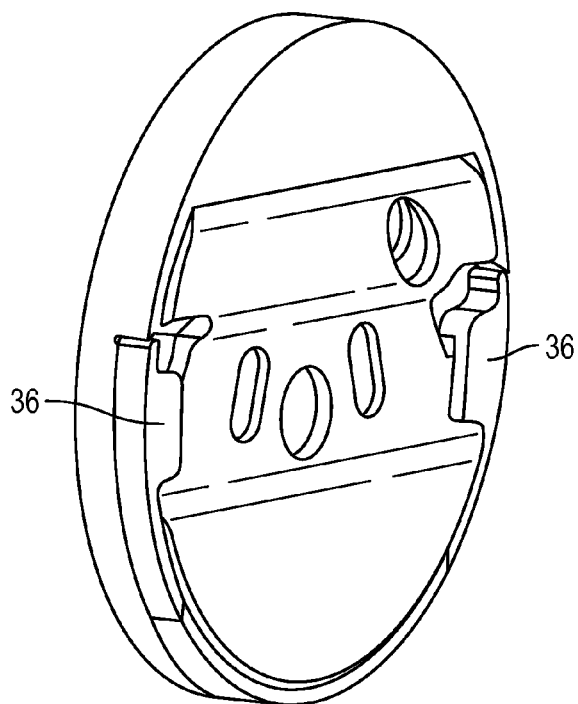


FIG. 10A

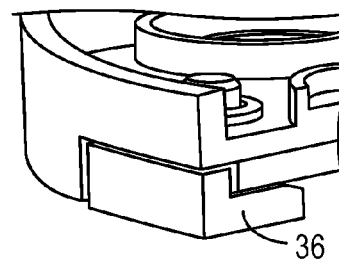


FIG. 10B

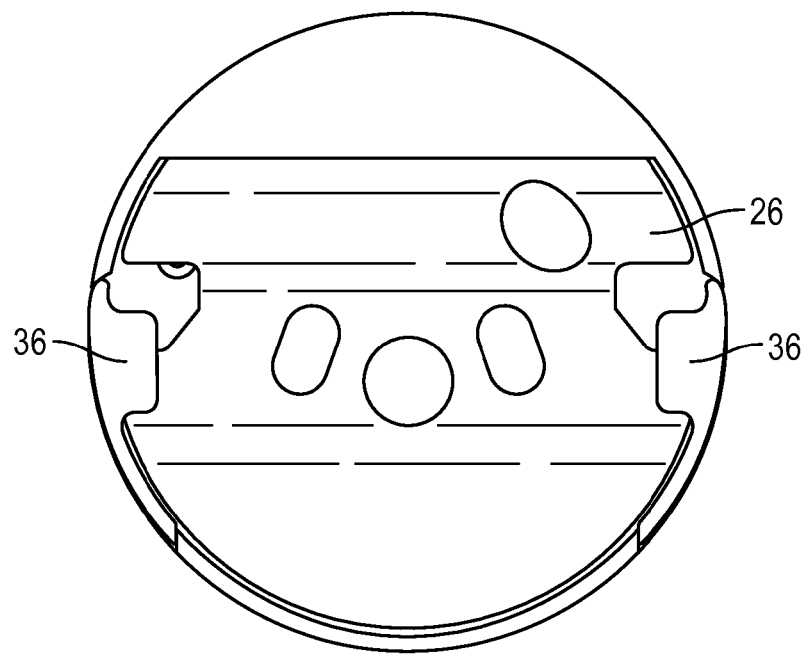


FIG. 10C

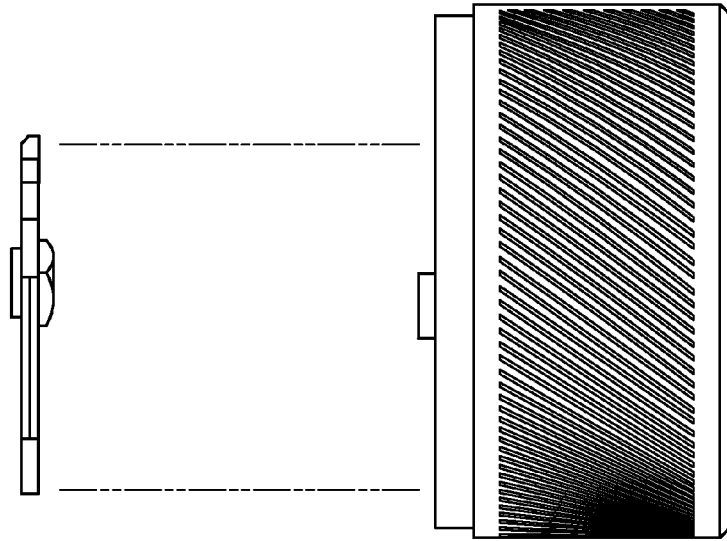


FIG. 11A

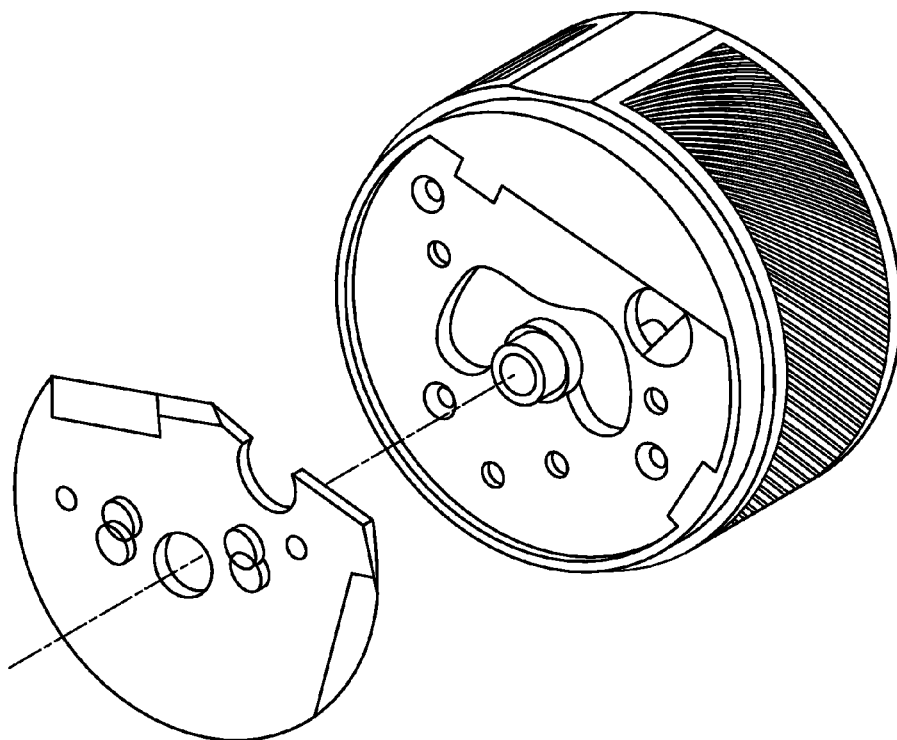


FIG. 11B

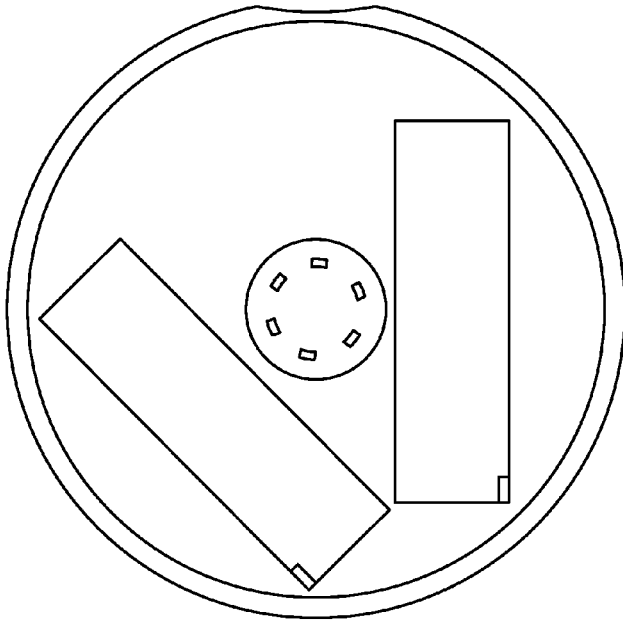


FIG. 11C

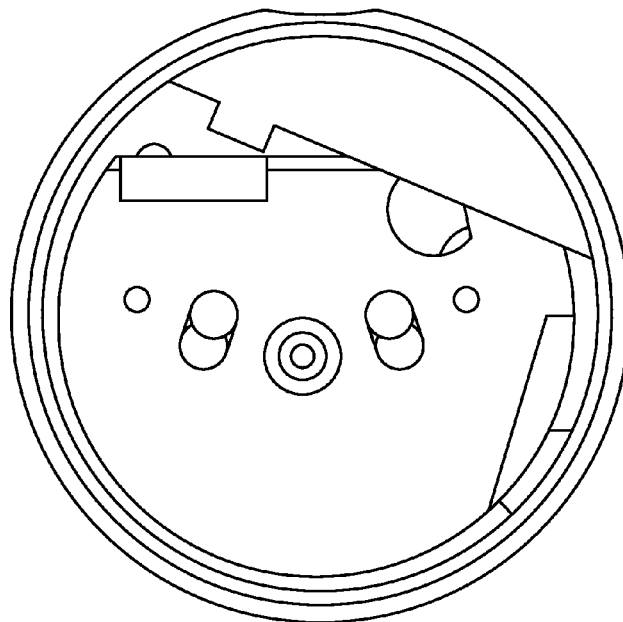
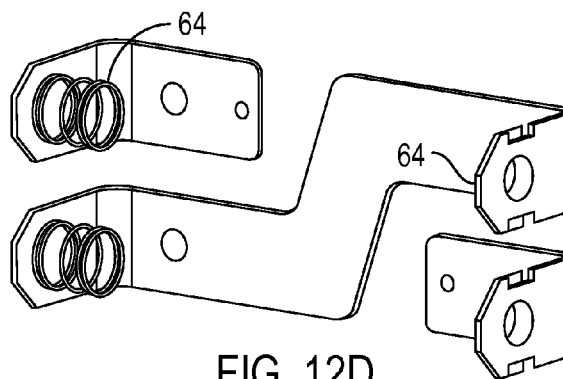
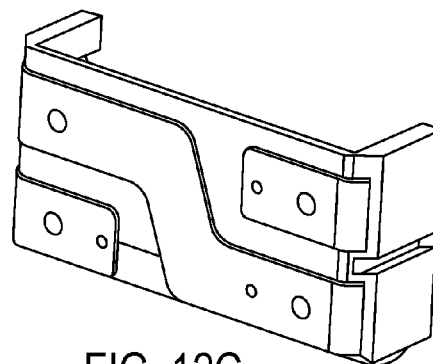
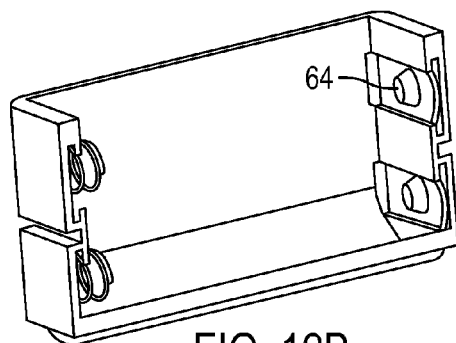
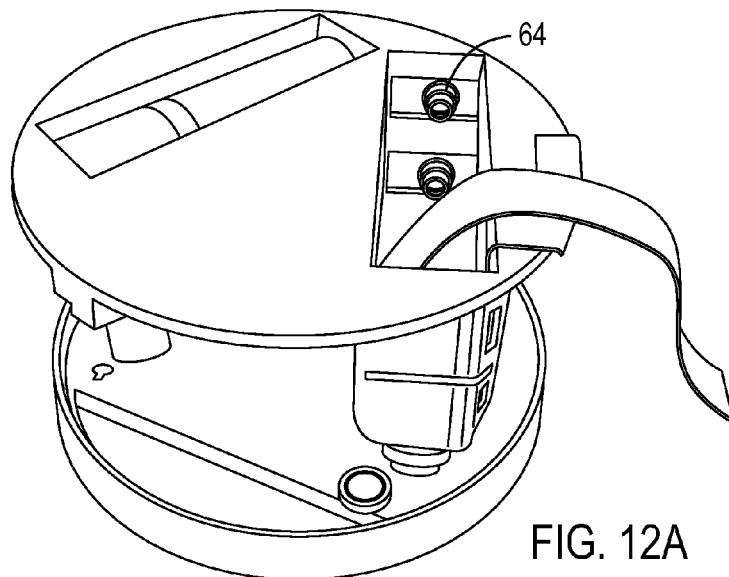


FIG. 11D



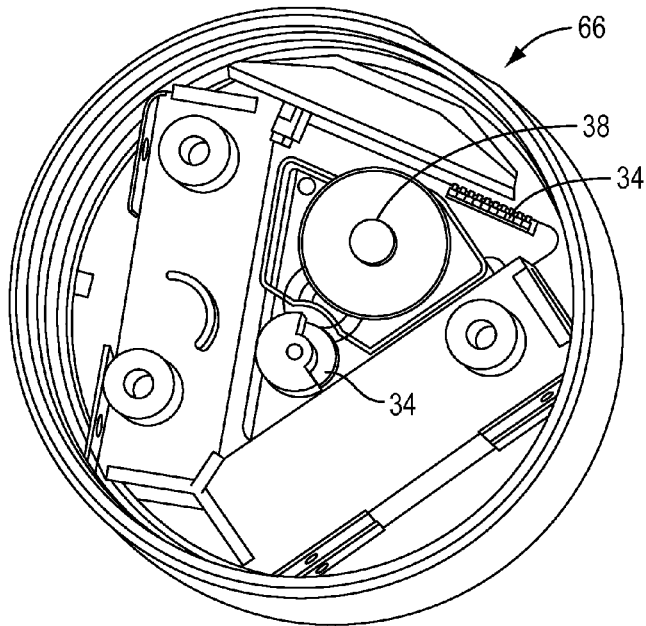


FIG. 13A

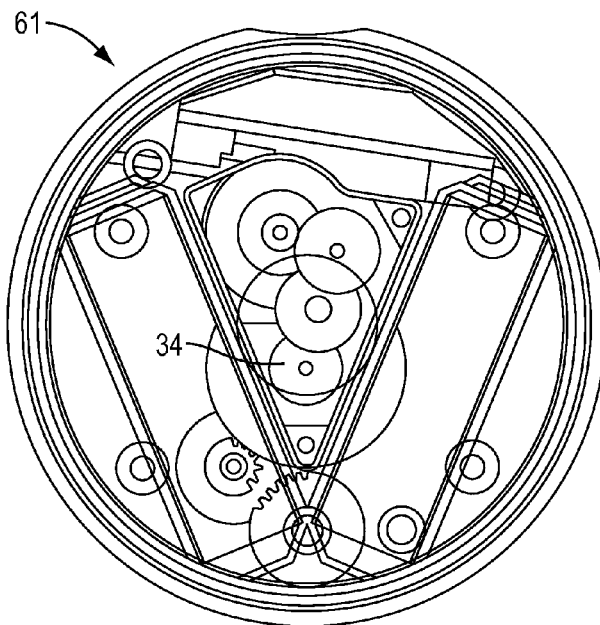


FIG. 13B

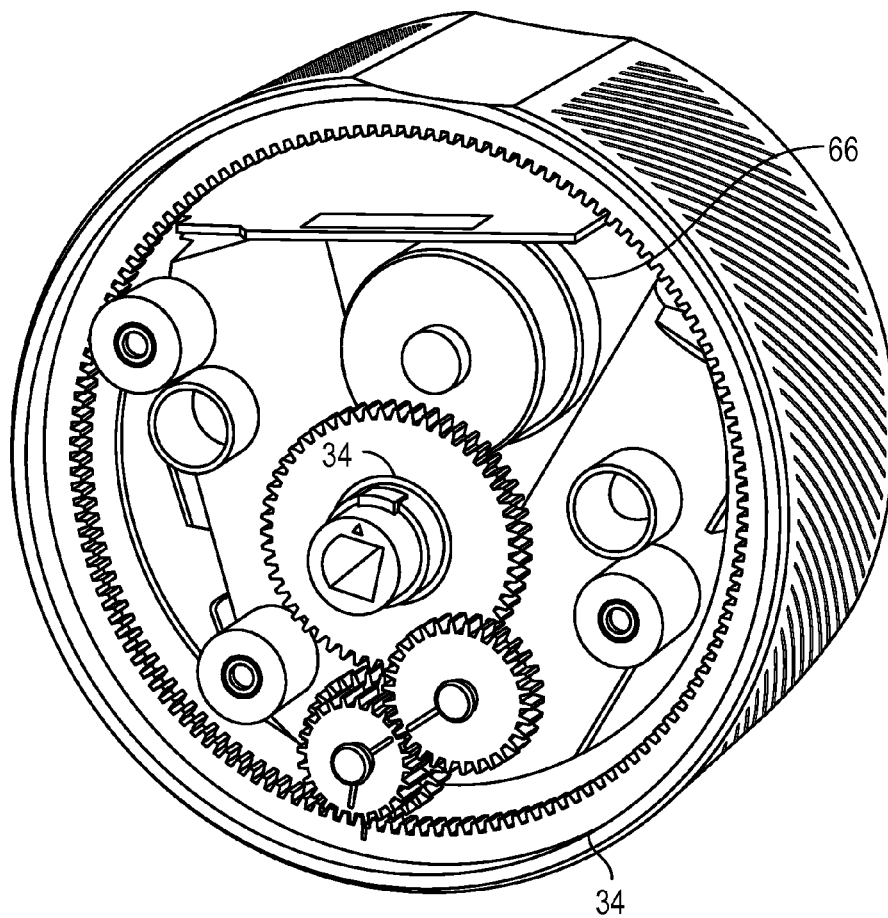


FIG. 14

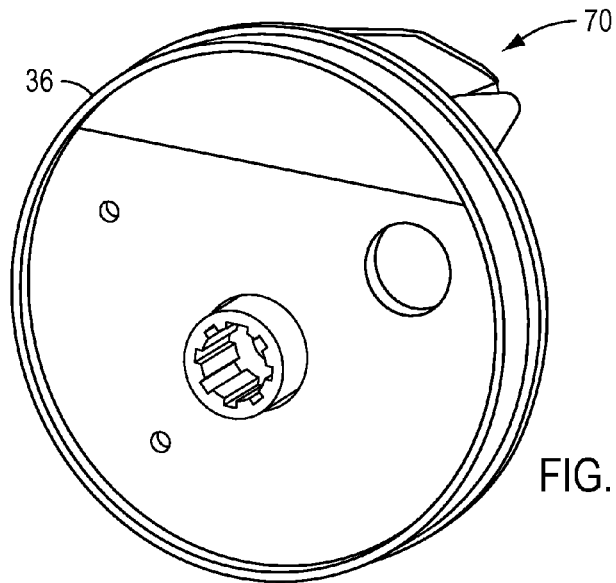


FIG. 15A

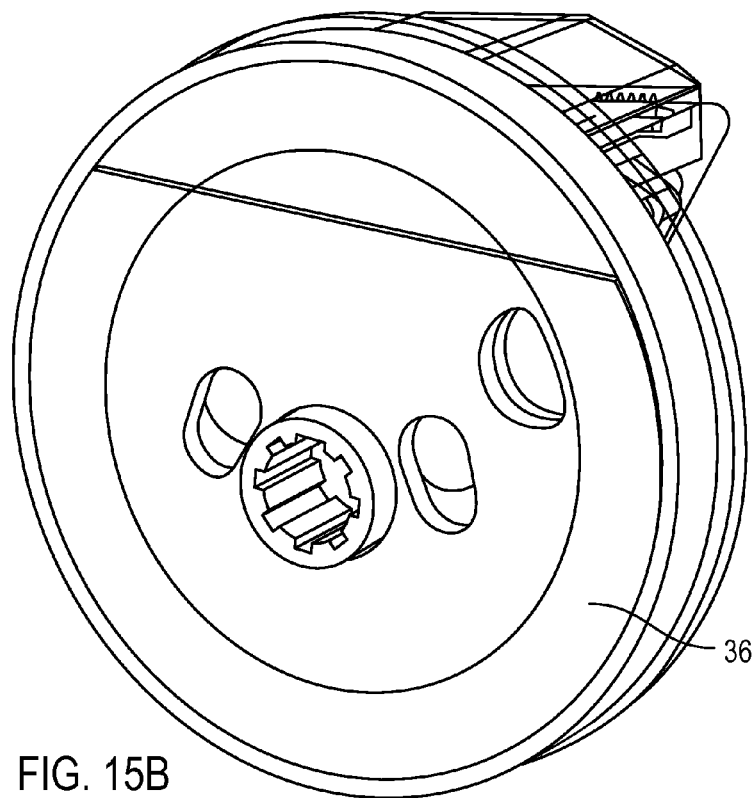


FIG. 15B

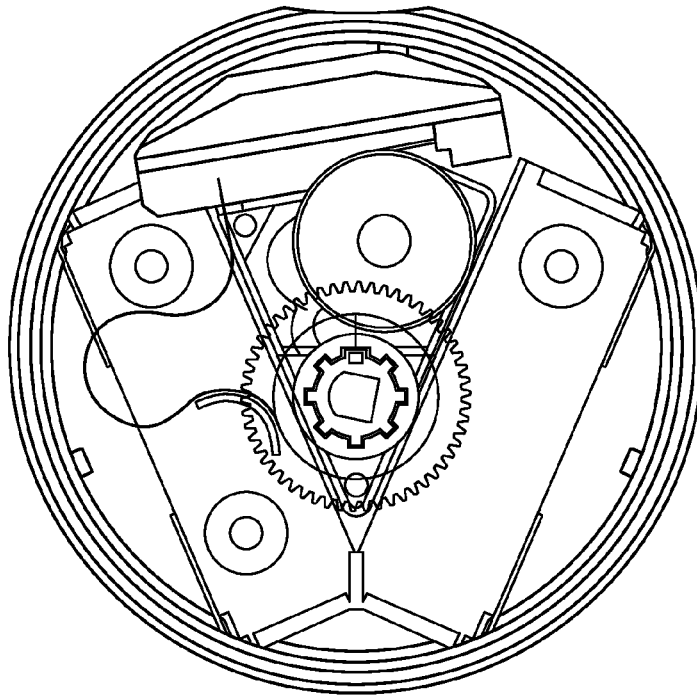


FIG. 15C

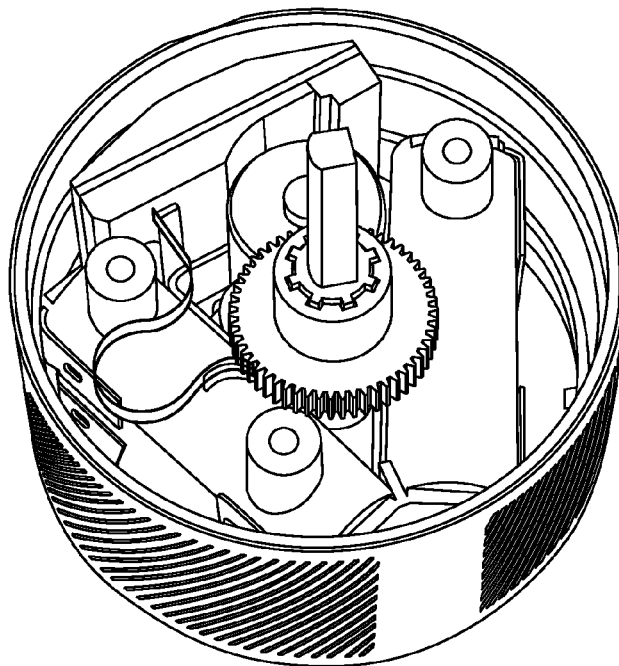


FIG. 15D

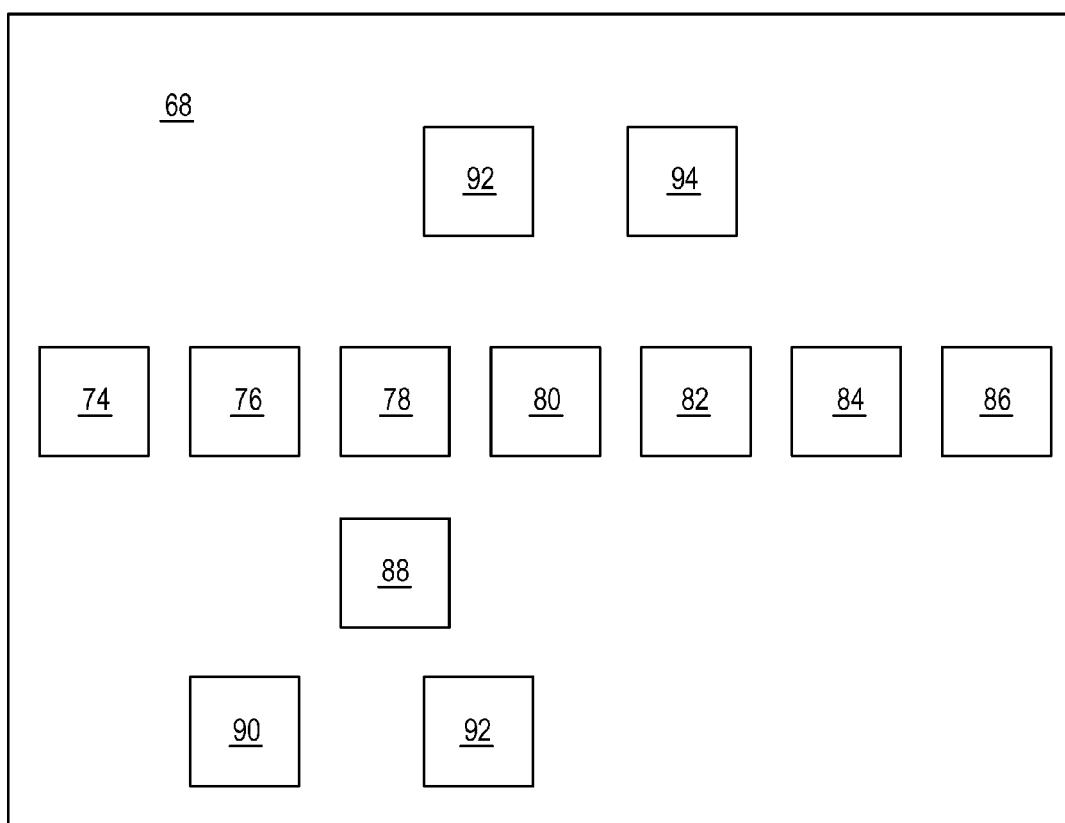


FIG. 16

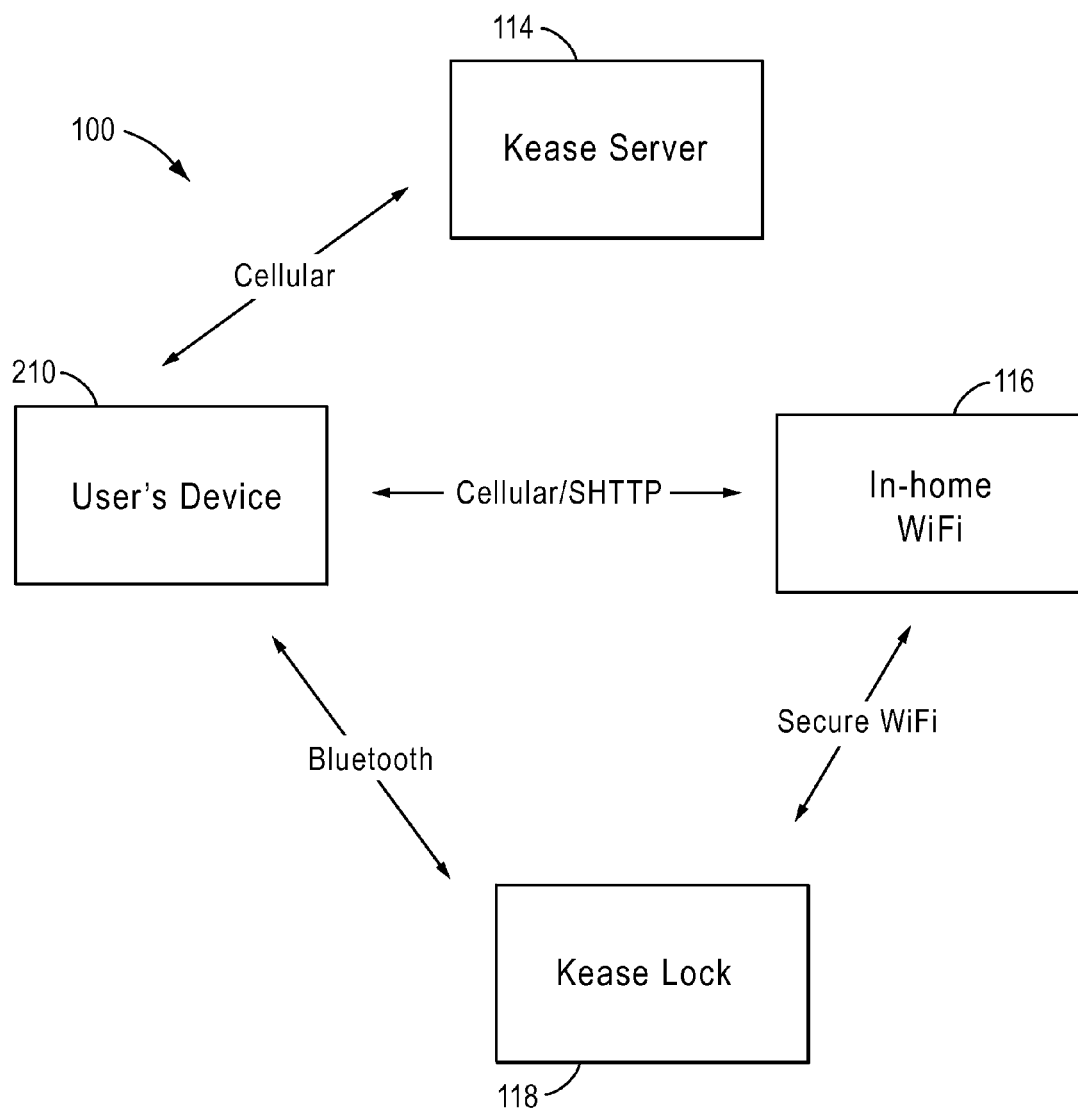


FIG. 17

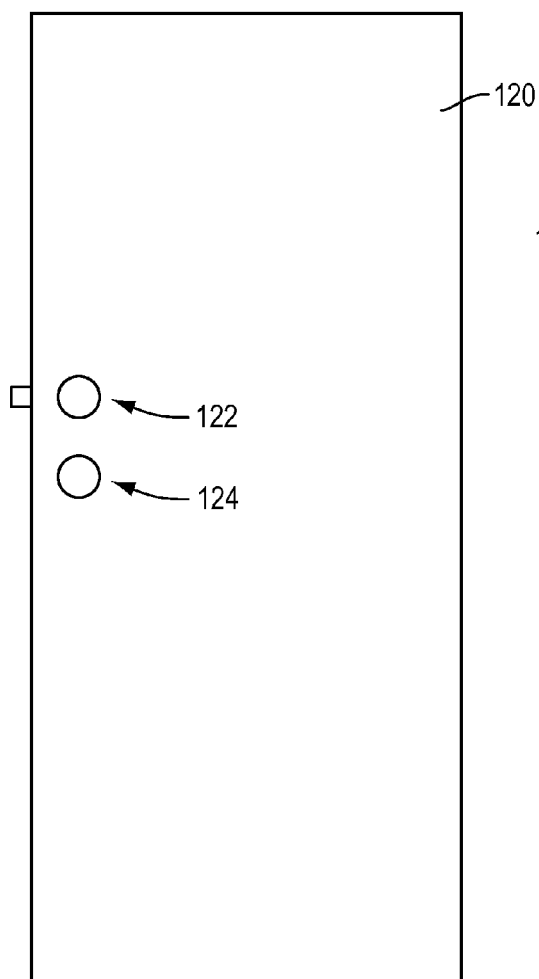


FIG. 18A

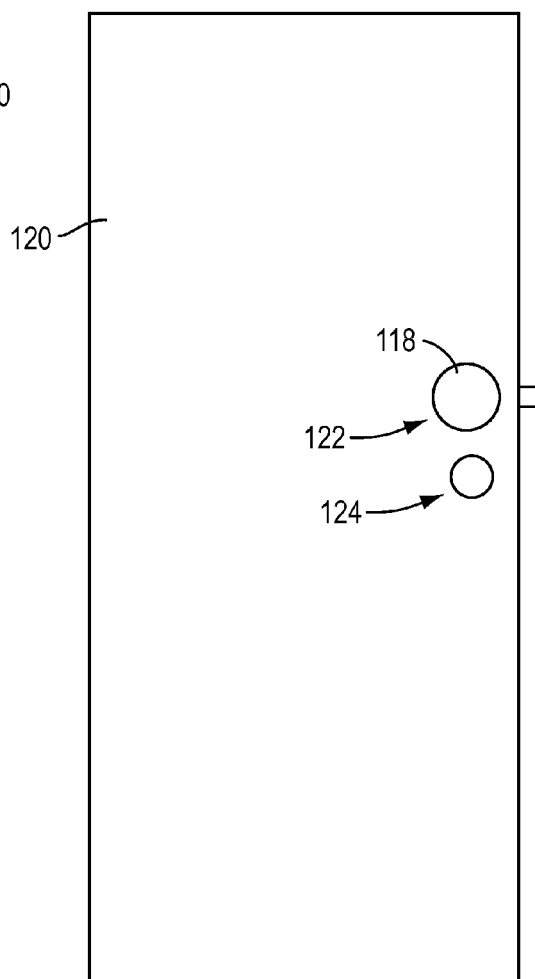


FIG. 18B

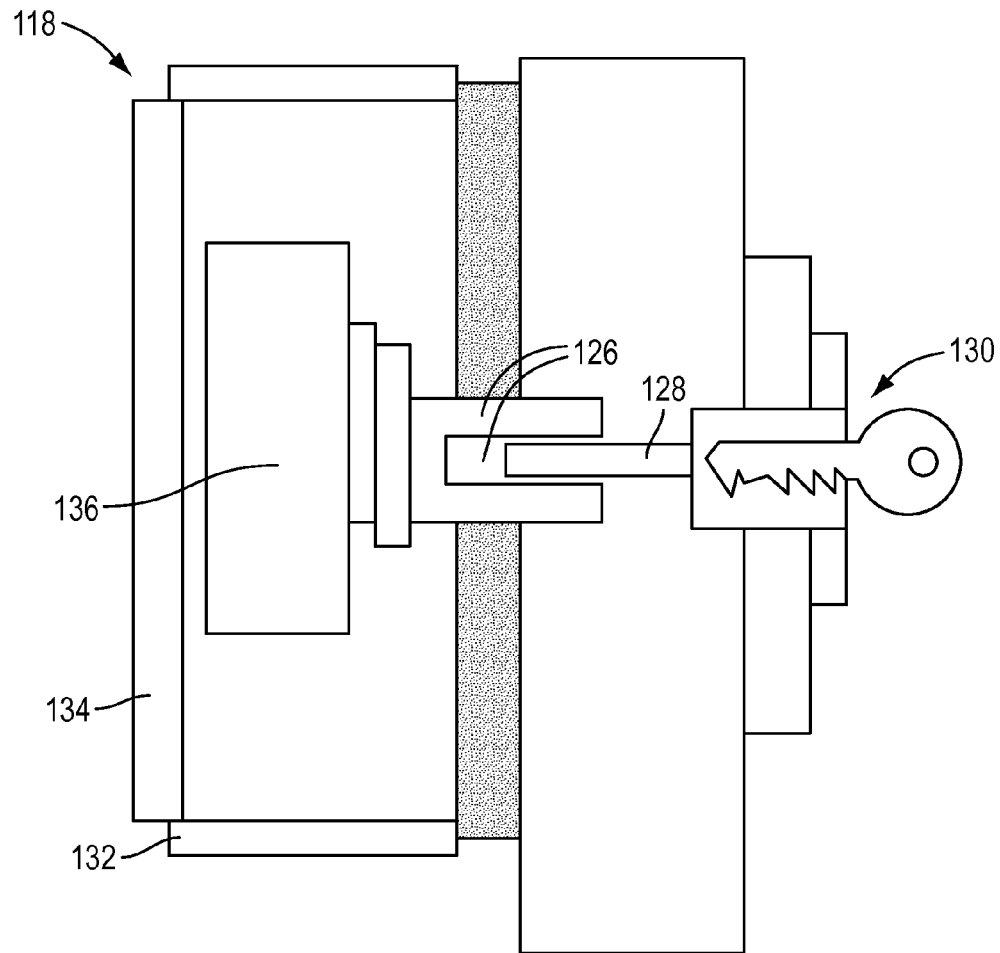


FIG. 19

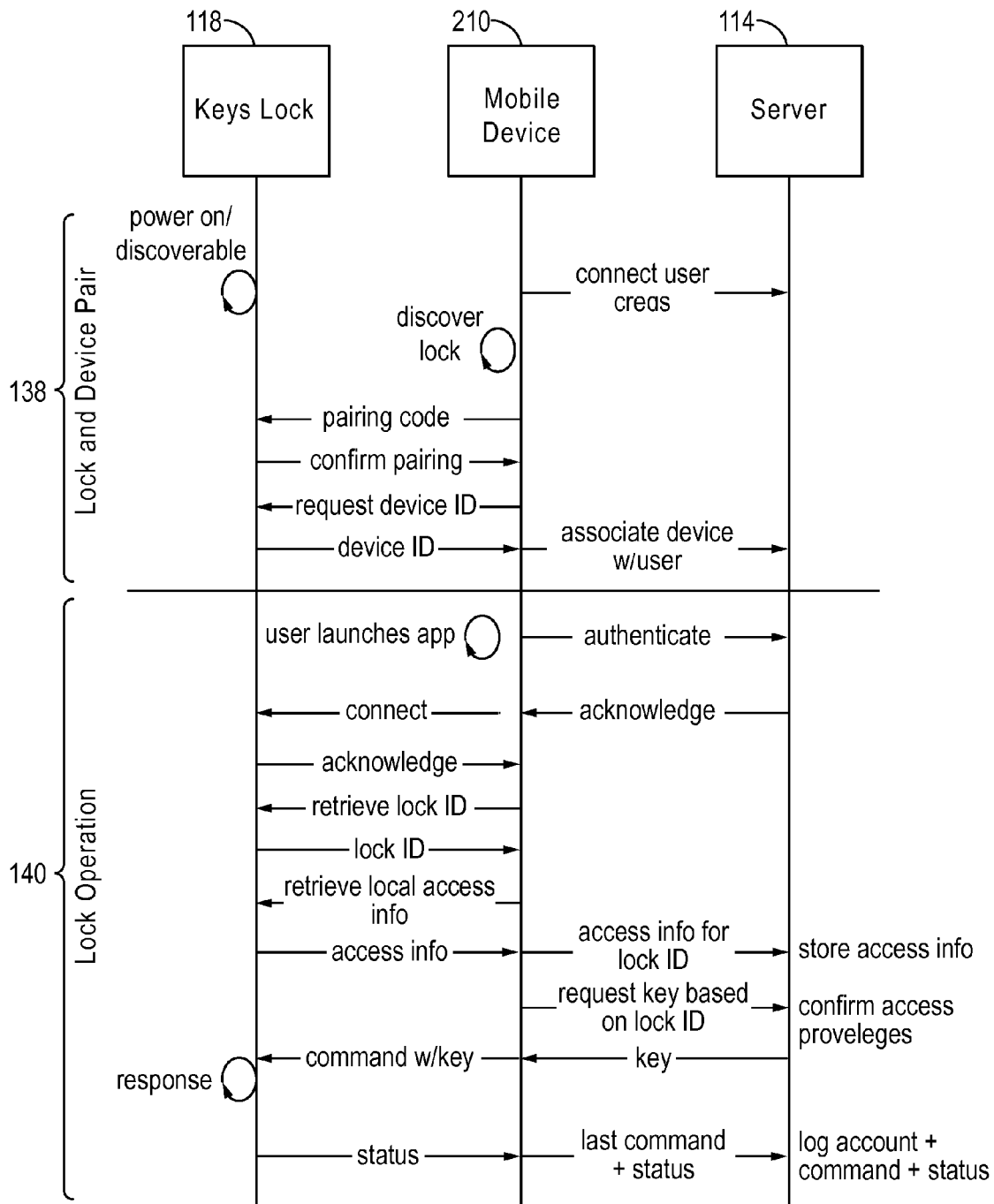


FIG. 20

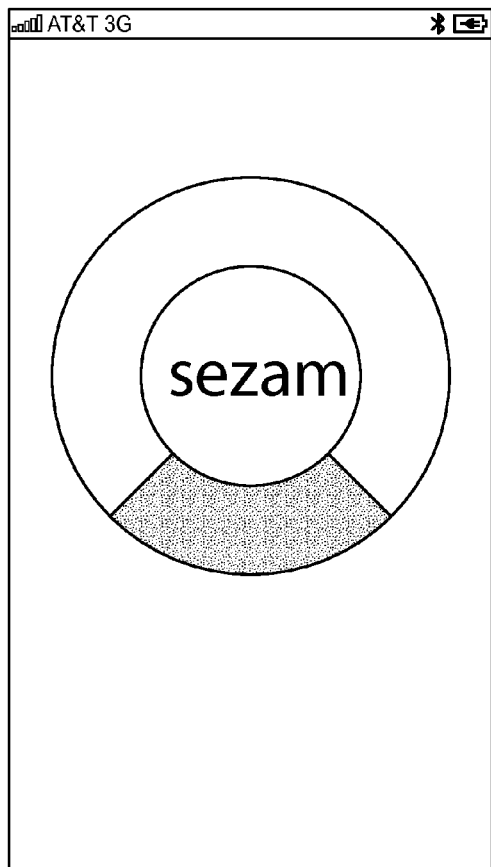


FIG. 21A

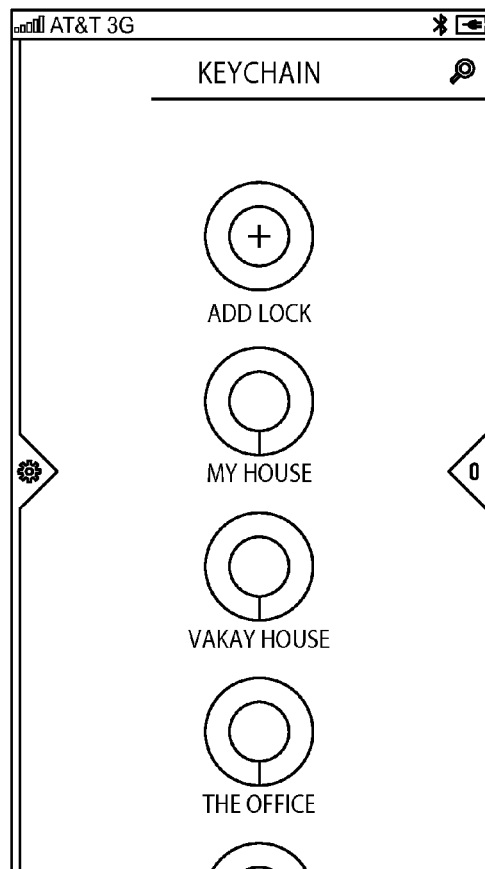


FIG. 21B

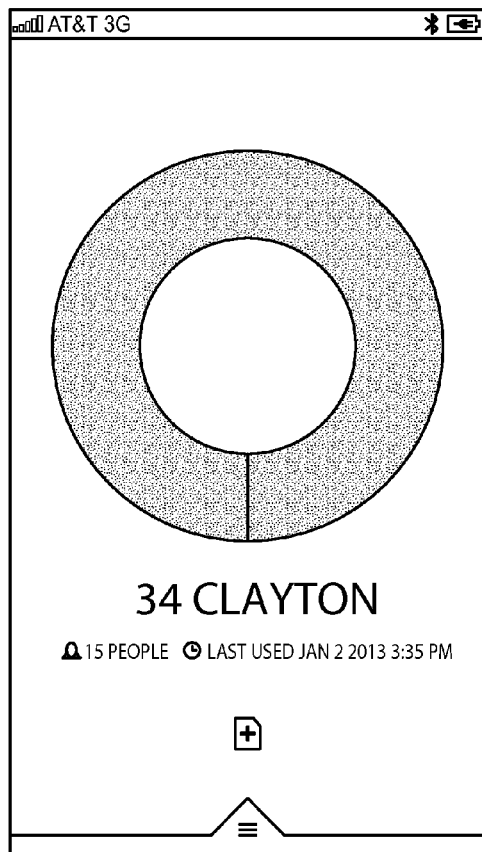


FIG. 21C

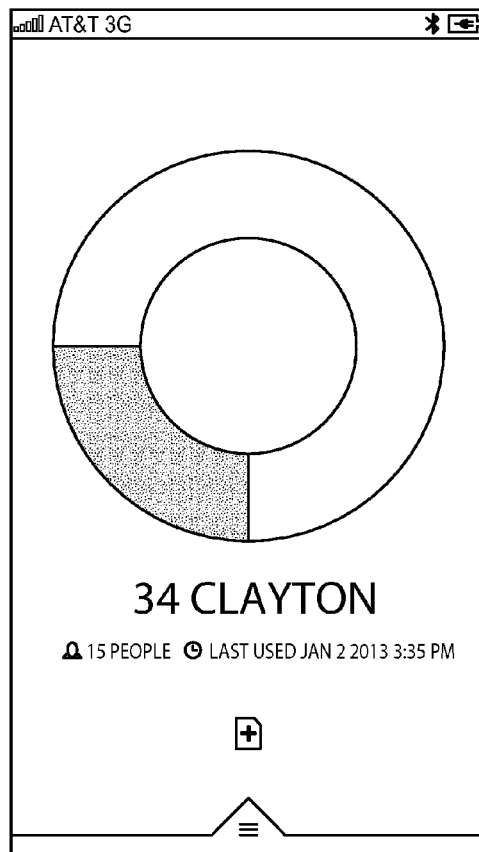


FIG. 21D

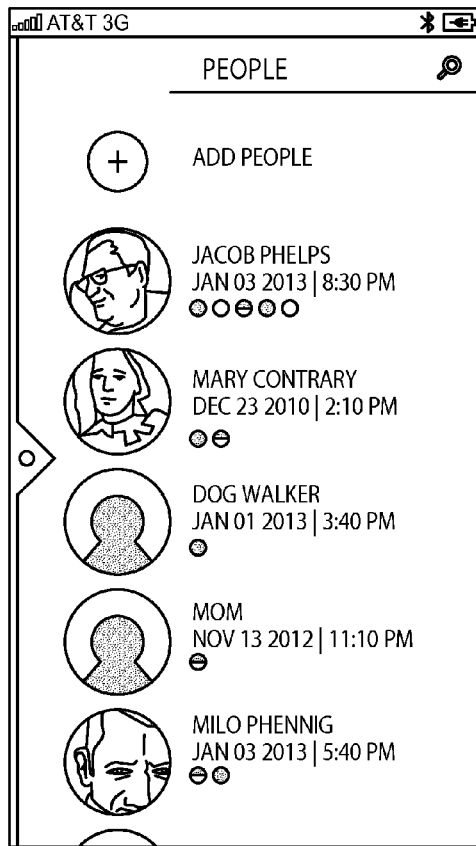


FIG. 21E

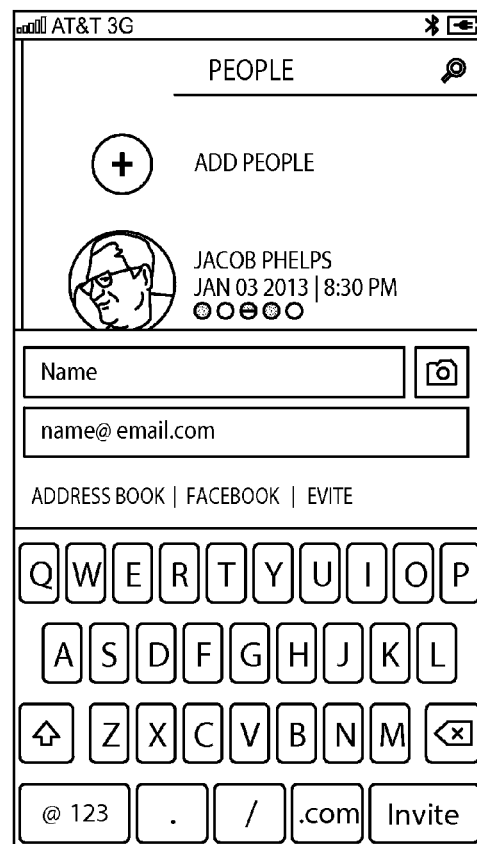


FIG. 21F

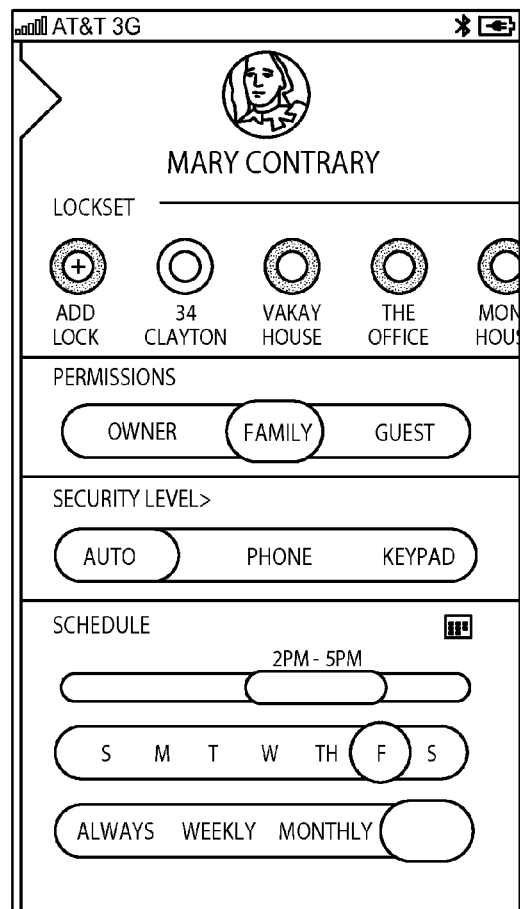


FIG. 21G

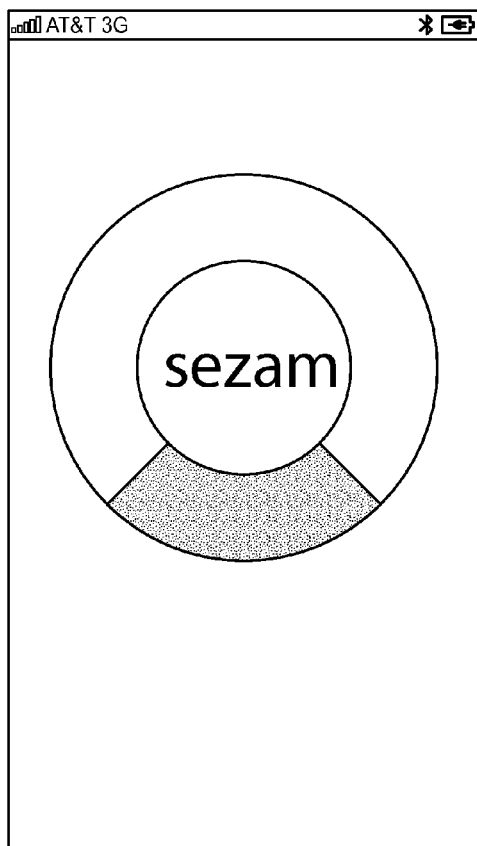


FIG. 22A

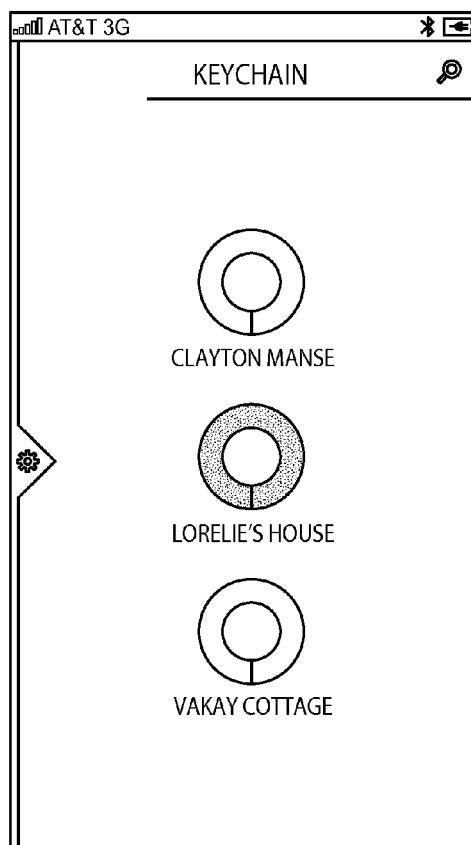


FIG. 22B

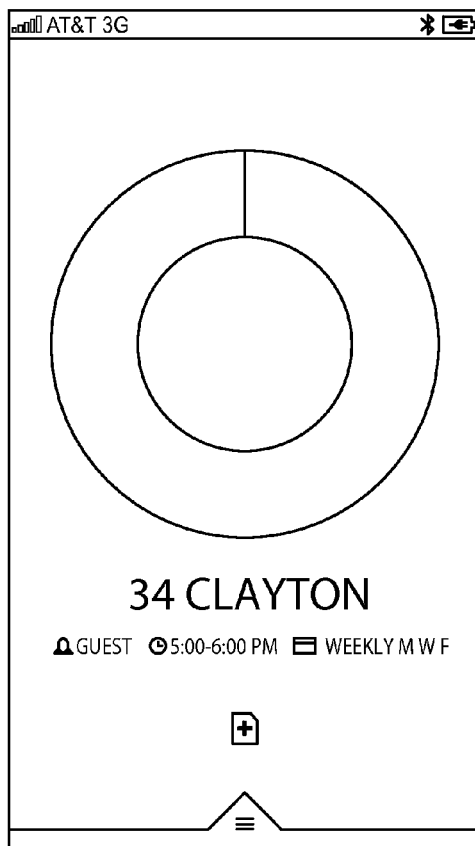


FIG. 22C

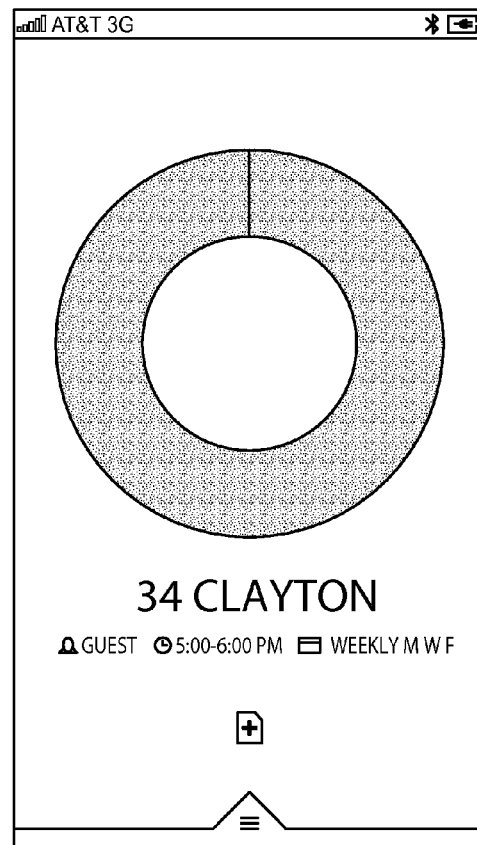


FIG. 22D

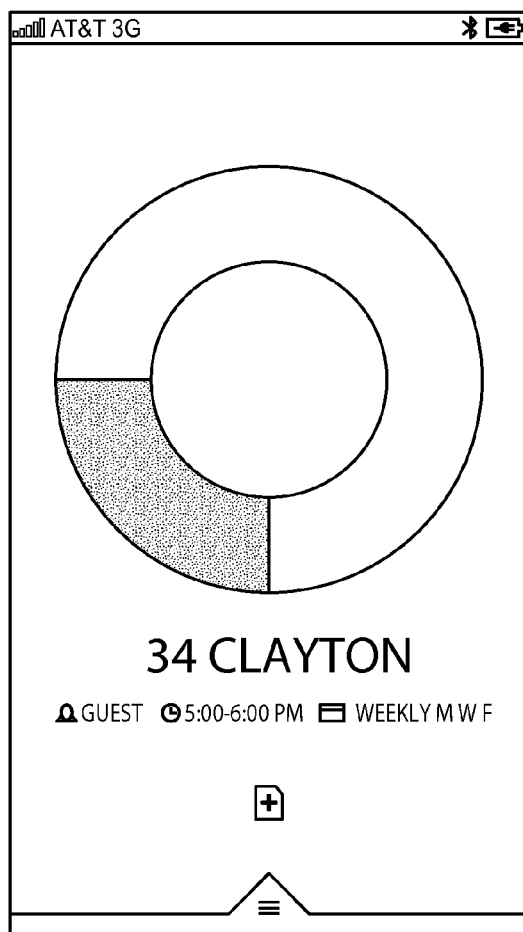


FIG. 22E

Empty Extension Gear

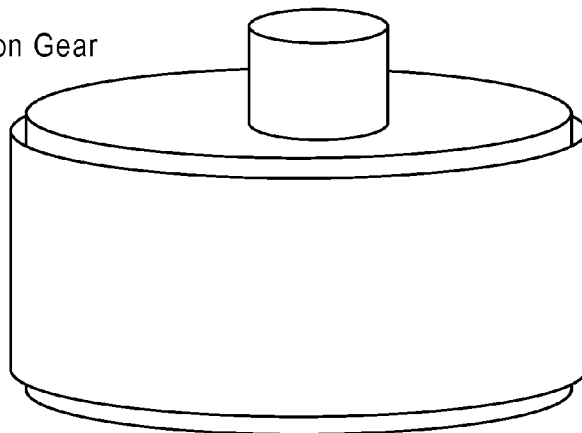
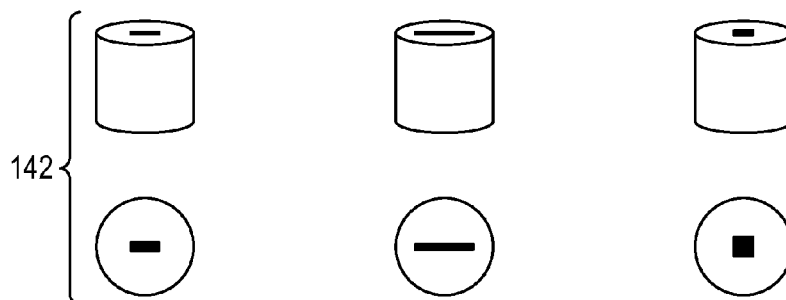
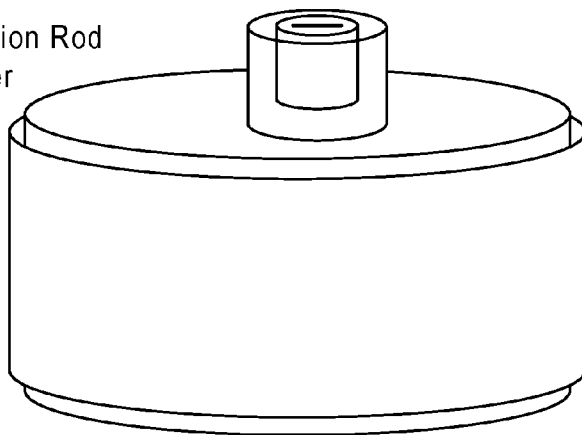


FIG. 23A

Modular Extension Rod
Controller



142

Extension Gear Adapters

FIG. 23B

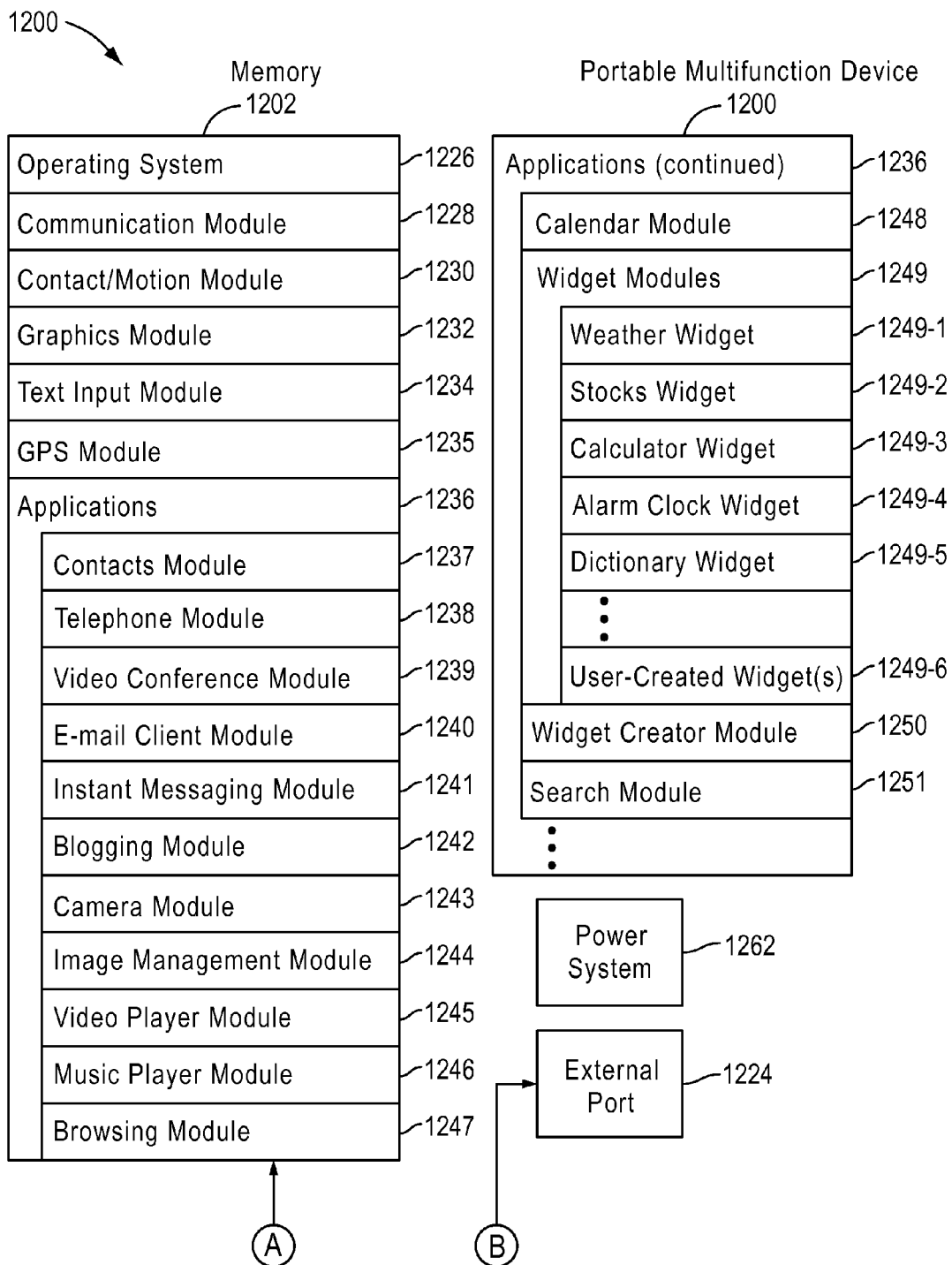


FIG. 24A

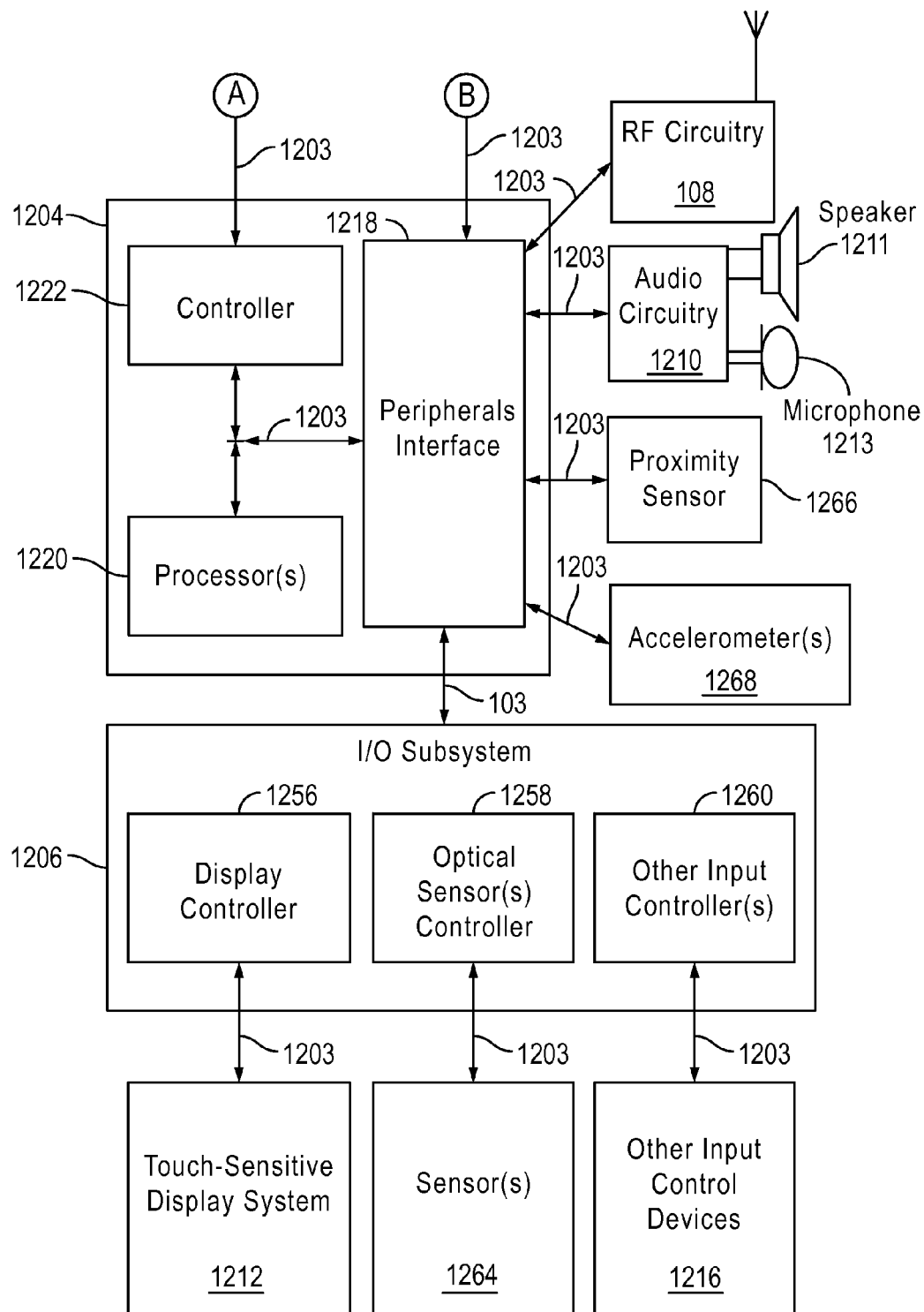


FIG. 24B

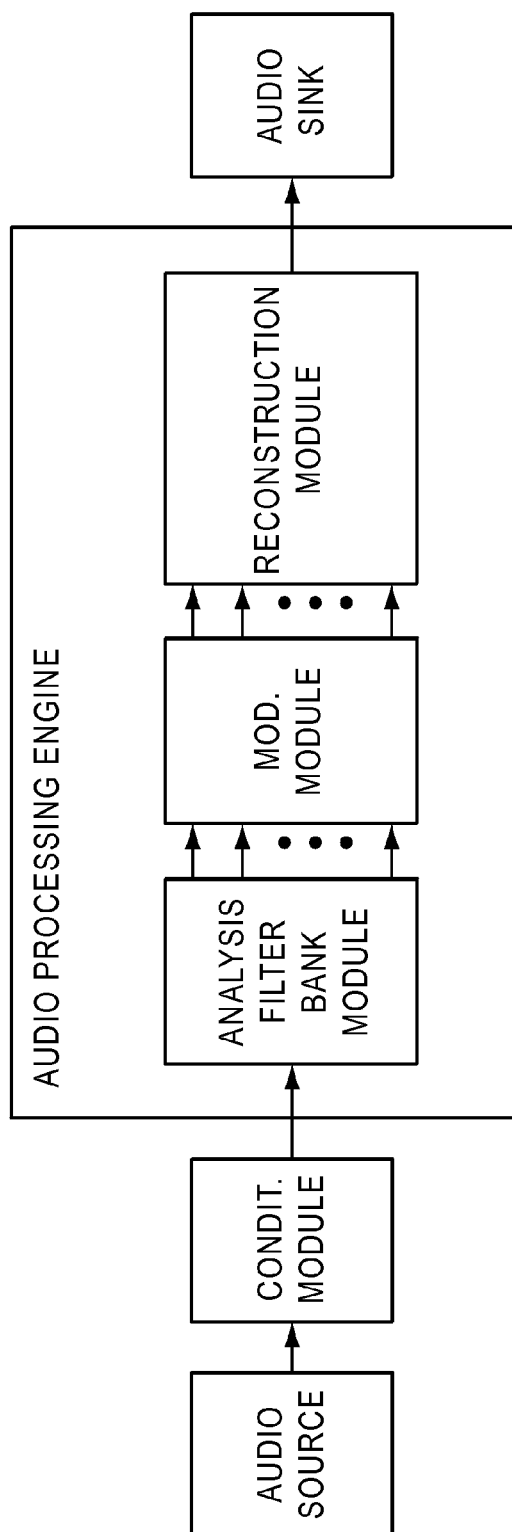


FIG. 25

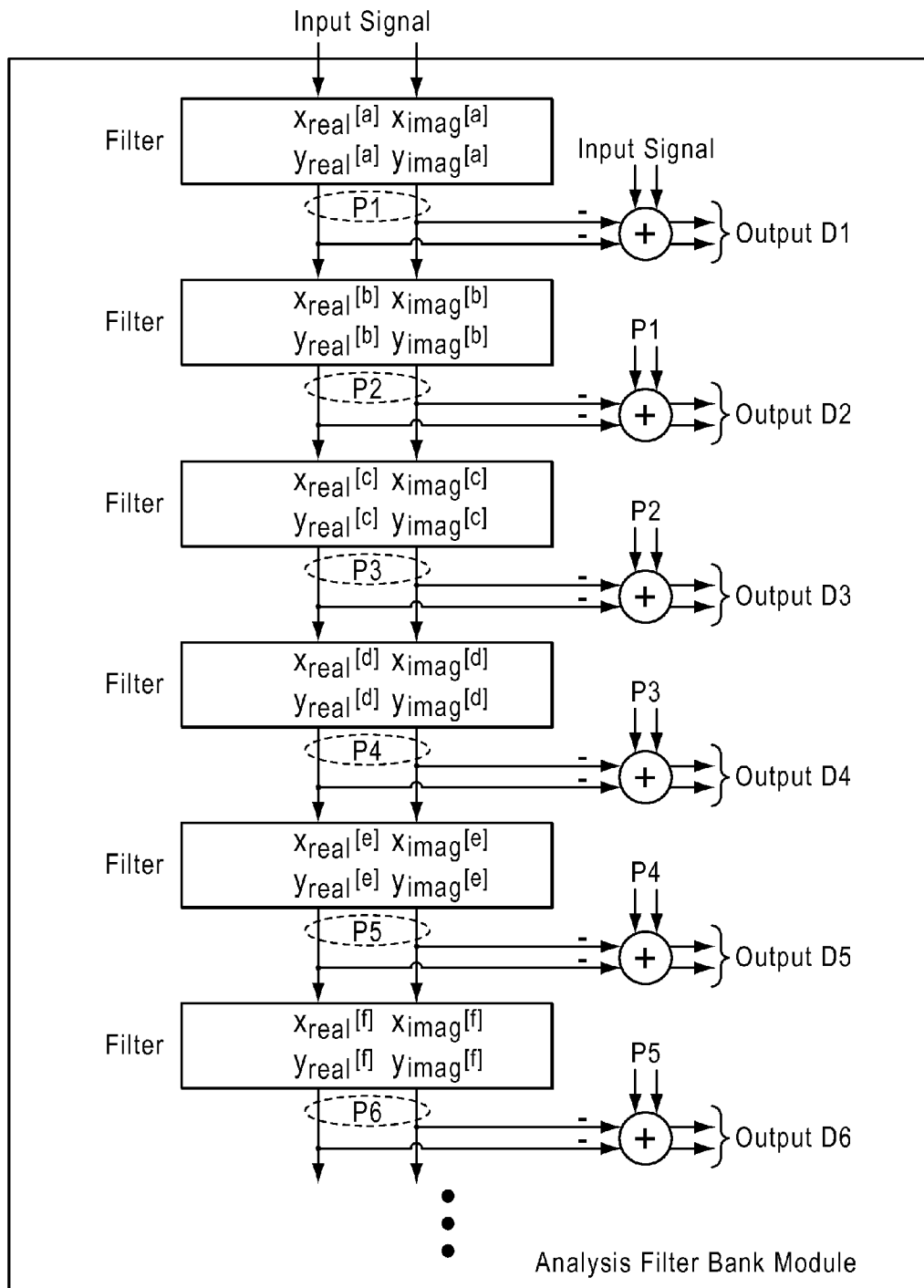


FIG. 26

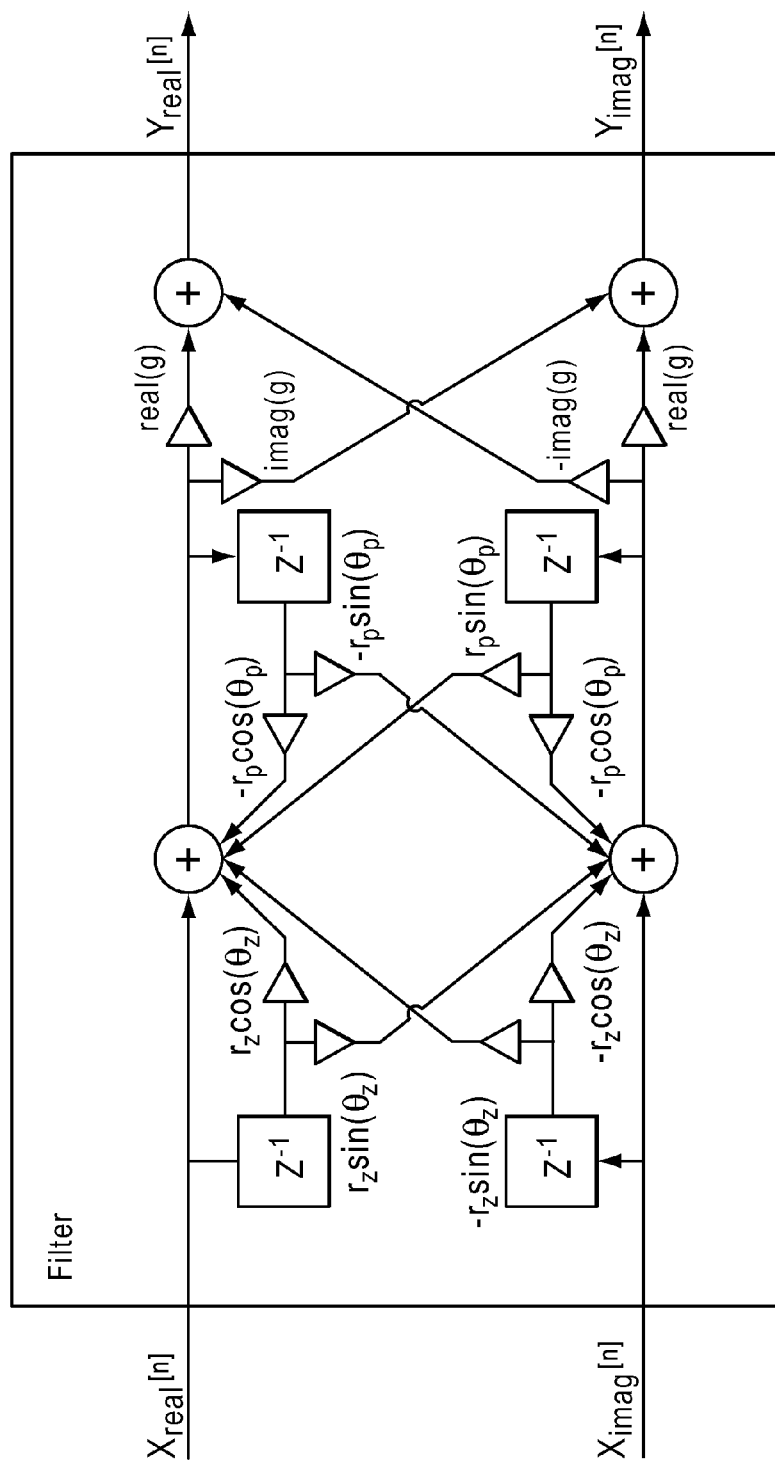


FIG. 27

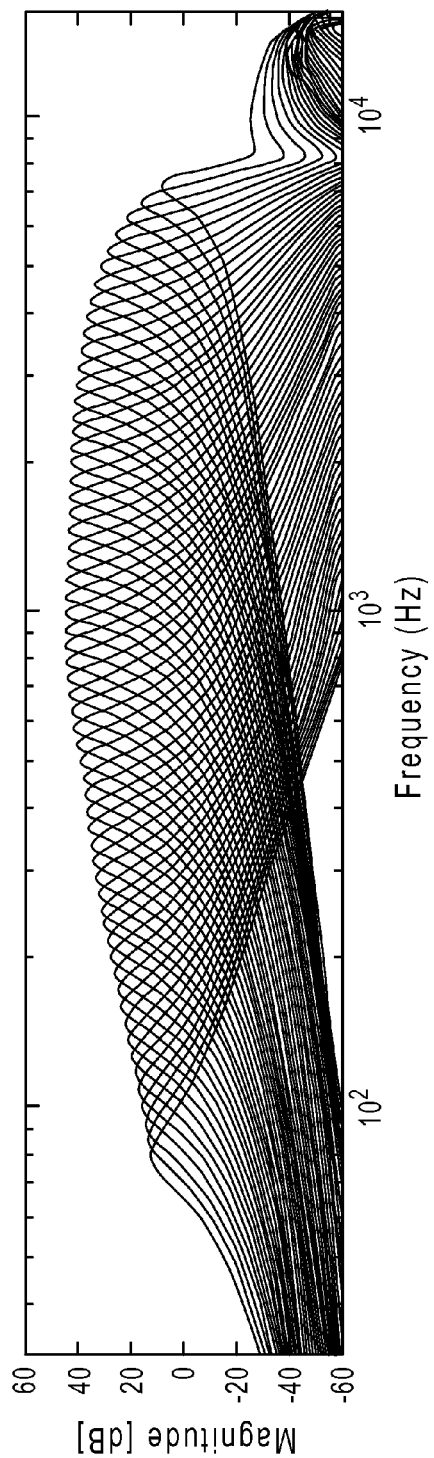


FIG. 28A

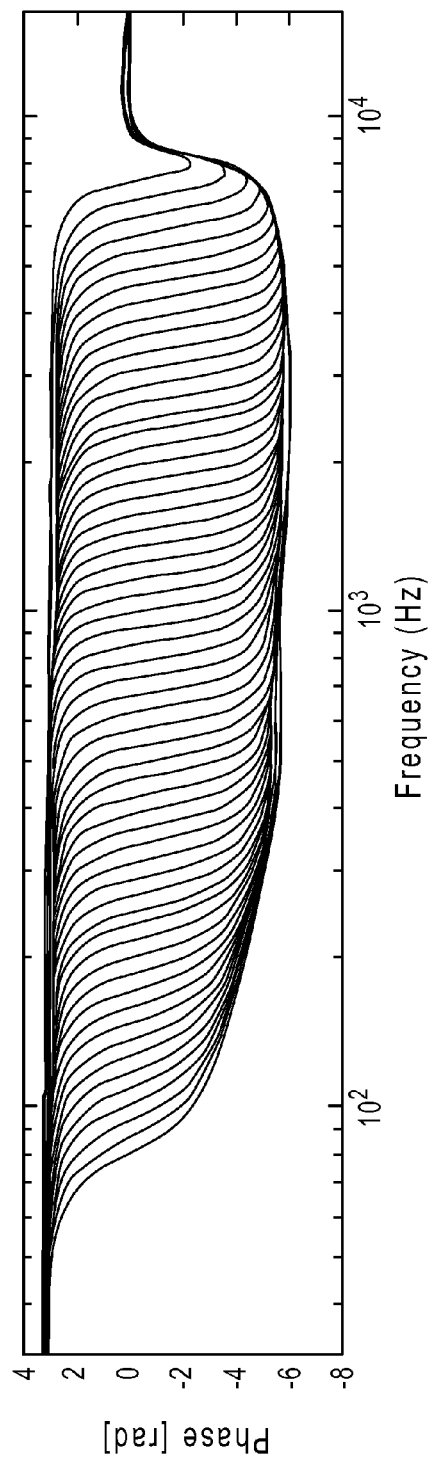


FIG. 28B

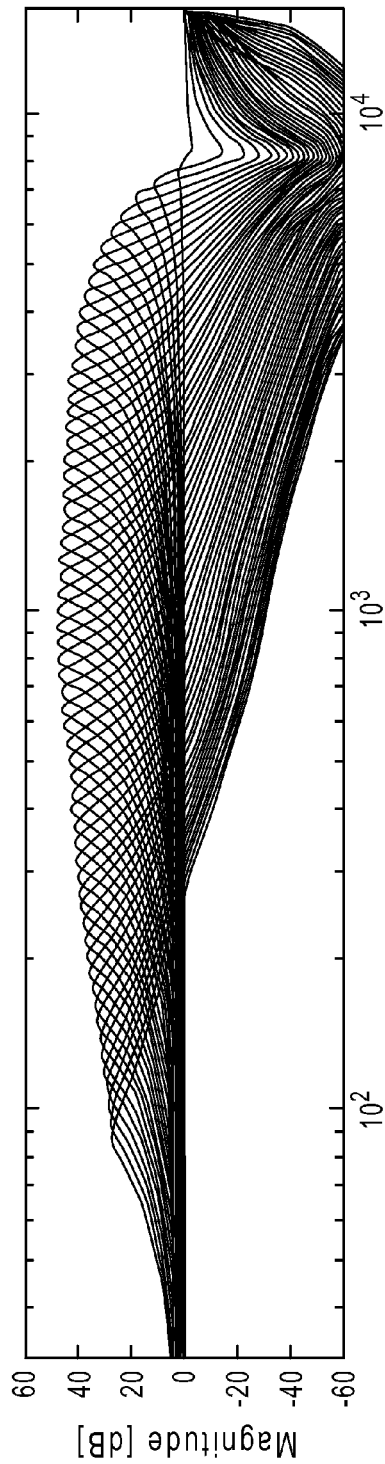


FIG. 29A

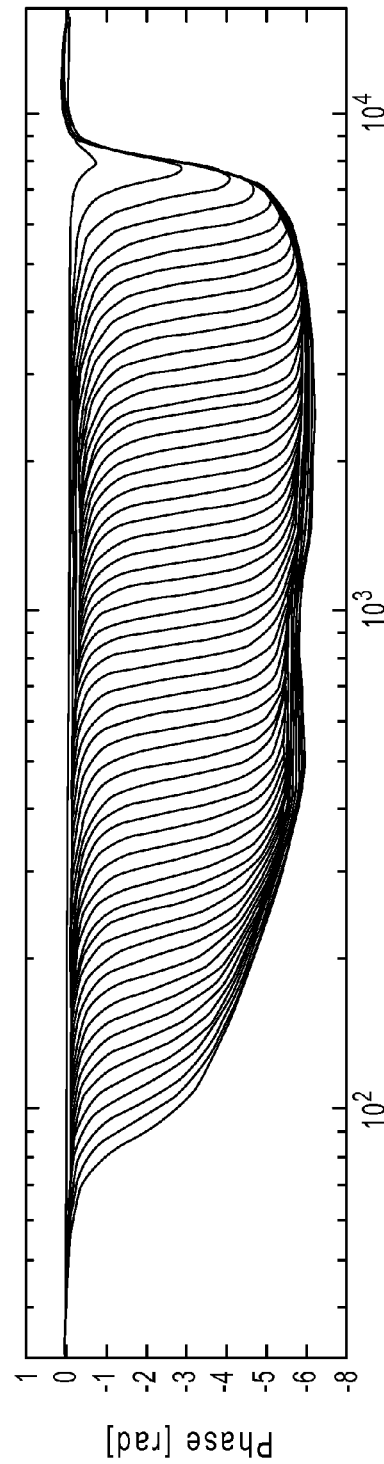


FIG. 29B

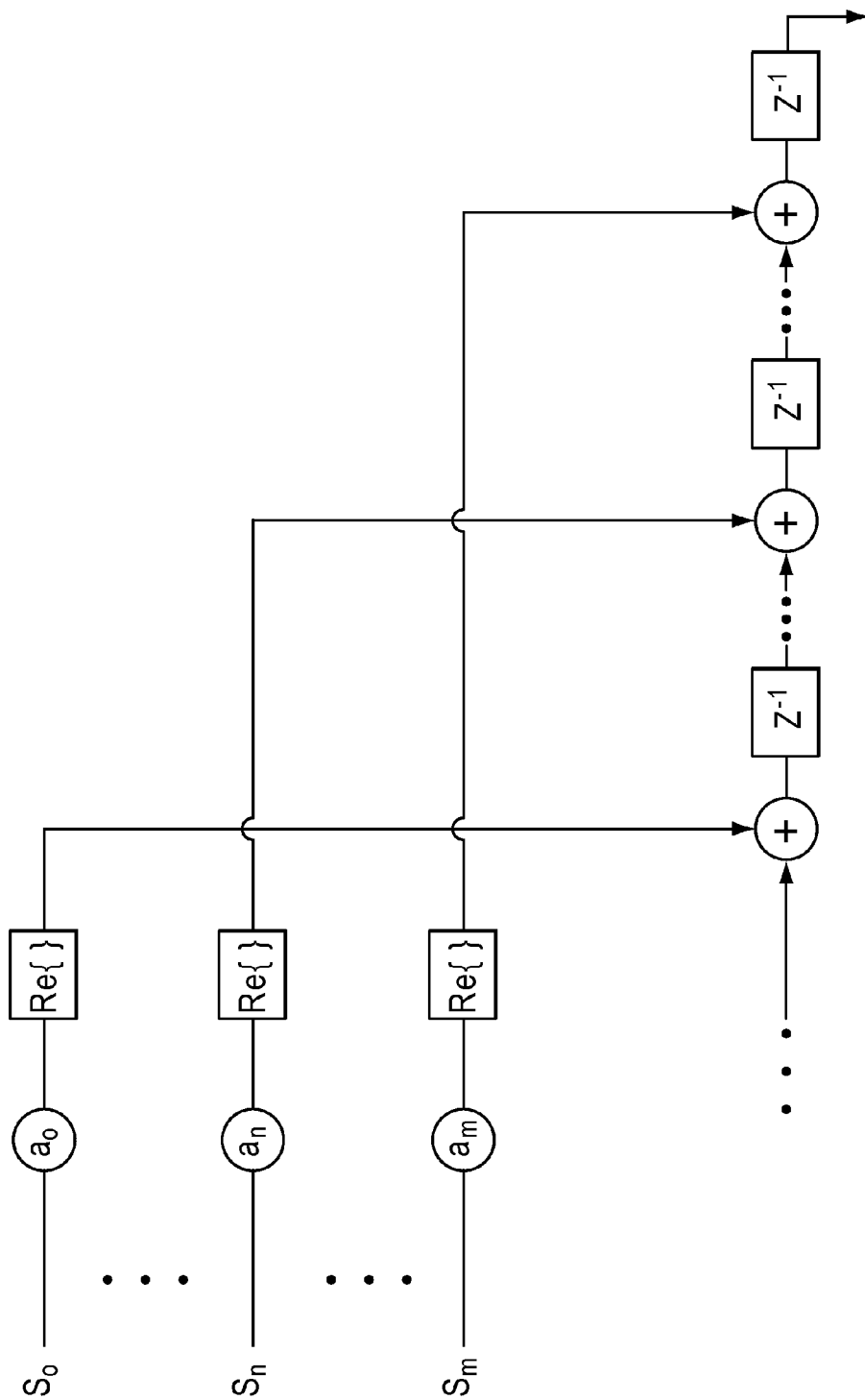


FIG. 30

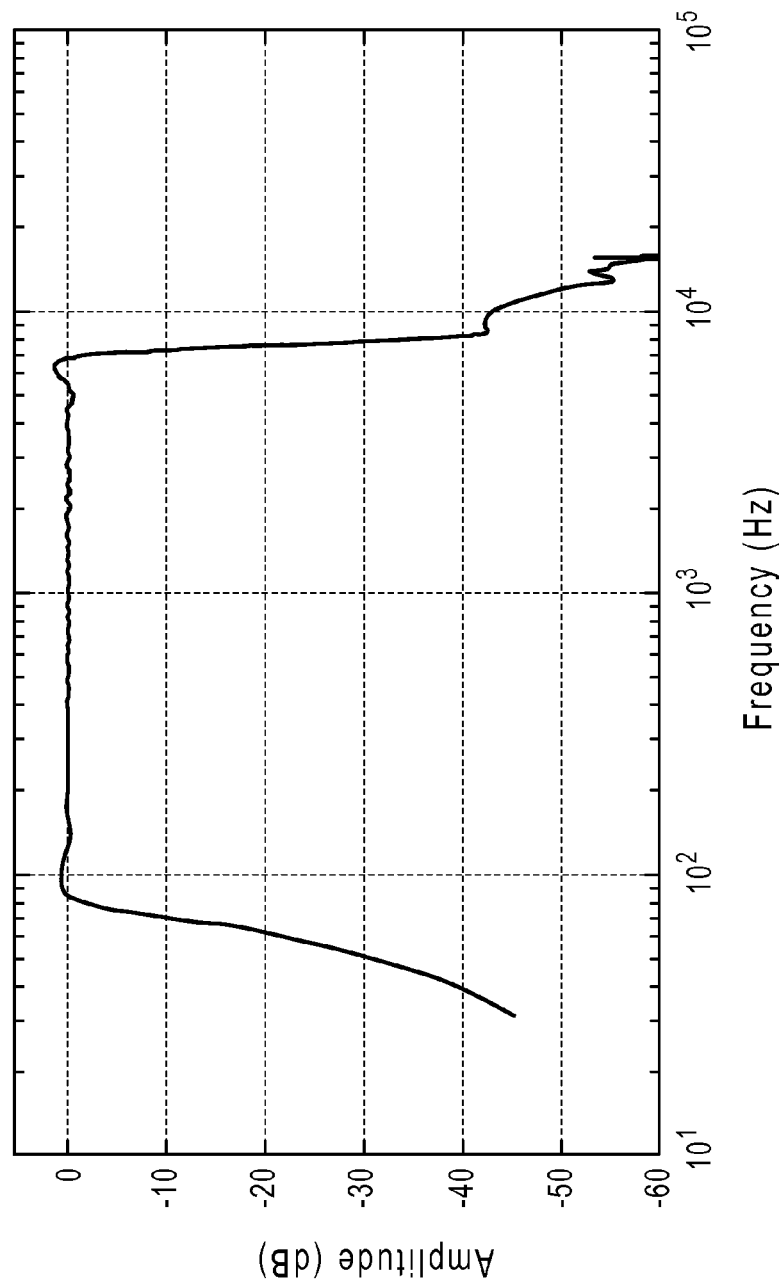


FIG. 31

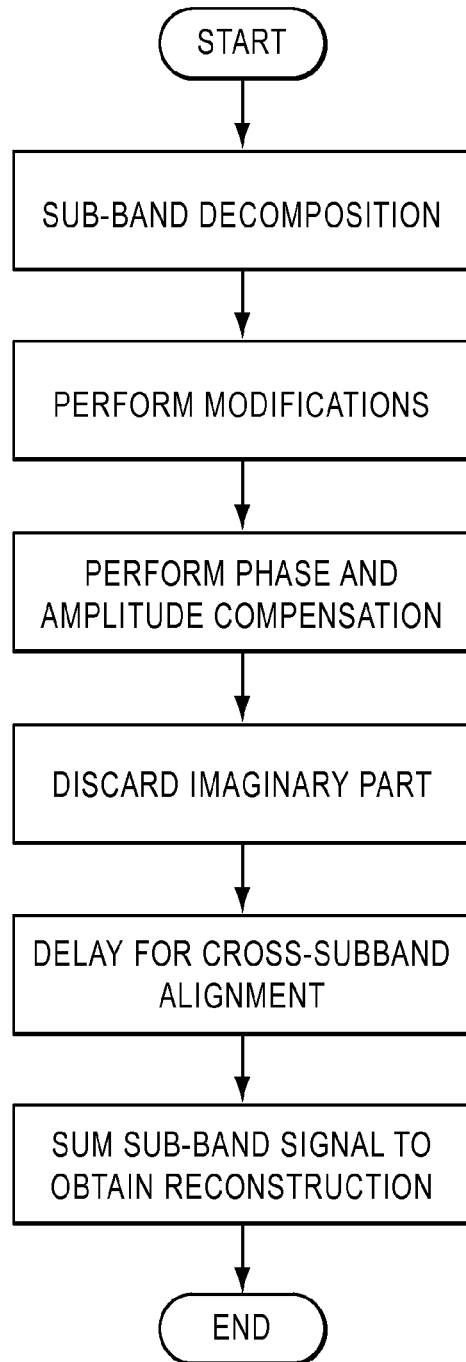


FIG. 32

BLE/WIFI BRIDGE WITH AUDIO SENSOR**CROSS REFERENCE TO RELATED APPLICATIONS**

This application is a continuation-in-part of U.S. patent application Ser. No. 14/459,054, filed Aug. 13, 2014 and U.S. patent application Ser. No. 14/205,608, filed Mar. 12, 2014, and claims the benefit of U.S. Provisional Patent Application Ser. No. 62/036,989, filed Aug. 13, 2014. The disclosures of the above referenced applications are incorporated herein by reference in their entirety.

BACKGROUND**1. Field of the Invention**

The present invention is directed to BLE/WiFi Bridge with Audio Sensors, and more particularly to BLE/WiFi Bridge with Audio Sensors for the at least partial analysis of a sound from a detector in a dwelling.

2. Description of the Related Art

Network bridging is the action taken by network equipment to create an aggregate network from either two or more communication networks, or two or more network segments. Bridging is distinct from routing which allows the networks to communicate independently as separate networks.

A network bridge is a network device that connects multiple network segments. In the OSI model bridging acts in the first two layers, below the network layer.

There are different types of network-bridging technologies including but not limited to: simple bridging; multipart bridging; learning; or transparent bridging; and source route bridging.

Most homes feature a router that provides a wireless network for network devices. Some advanced users might look to expand their wireless capability, adding users, devices and range. Most routers have a bridging mode that helps expand network capability, but you need to know how it works and how to properly utilize the feature.

A bridging mode is a solution for network expansion. Bridging allows two or more wireless access points to communicate in order to connect multiple local area networks (LAN). Bridging is an option available in most router firmware.

A WiFi bridge is a device based on the 802.11 protocol that is used to add desktop computers and printers in remote locations to the network without having to string cables and without having to equip each one with a Wi-Fi adapter. Commonly called a "wireless bridge" without Wi-Fi in the name, the bridge has a built-in LAN switch for plugging in several devices, and like all Wi-Fi hotspots, does not require line-of-site. It can be set up almost anywhere and transmit over the air to another Wi-Fi bridge or access point that is wired to the main network.

Some Wi-Fi bridges are designed to connect to only one device. In addition, long-distance bridges may require line-of-site. See wireless bridge, power line network, cellular hotspot, wireless game adapter and 802.11.

Alarm systems are used by consumer and industrial users to provide improved safety and security of residences and industrial facilities. These alarm systems typically include an alarm panel which receives and monitors signals from a host of peripheral devices, including keypads, various sensors and warning devices. The control panels, upon receiving notice of an alarm condition typically report to a remote central station over a telephone line or other communication path.

Alarm systems can be divided into hard wired systems where the alarm panel is hard wired to the various peripheral devices such as smoke detectors, motion detectors, etc., or a wireless system where these devices communicate with the alarm panel using RF transmissions, for example. In wireless systems, each of the peripheral devices has their own battery power source and the number and type of transmissions are managed to conserve power while providing positive communication. There are also alarm systems which use a combination of hard wired and RF peripheral devices.

Each alarm system typically has a number of sensors which report to the alarm panel. Updating of systems or extending of the systems can include the addition of more current sensors and/or the replacement of certain sensors with more current sensors. It is also possible to update or replace the alarm panel, however, in many cases; this is not practical from a cost standpoint as the entire alarm system is typically replaced.

Generally, smoke detectors detect the presence of smoke particles as an early indication of fire. Smoke detectors are typically used in closed structures such as houses, hotels, motels, dormitory rooms, factories, offices, shops, ships, aircraft, and the like. Smoke detectors may include a chamber that admits a test atmosphere while blocking ambient light. A light receiver within the chamber can receive a level of light from an emitter within the chamber, which light level is indicative of the amount of smoke contained in the test atmosphere.

Several types of fires can generally be detected. A first type is a slow, smoldering fire that produces a "gray" smoke containing generally large particles, which may be in the range of 0.5 to 1.2 microns. A second type is a rapid fire that produces "black" smoke generally having smaller particles, which may be in the range of 0.05 to 0.5 microns. Fires may start as one type and convert to another type depending on factors including fuel, air, confinement, and the like.

Generally, two detector configurations have been developed for detecting smoke particles. One exemplary type of detector is a detector that aligns the emitter and receiver such that light generated by the emitter shines directly into the receiver. Smoke particles in the test atmosphere interrupt a portion of the beam thereby decreasing the amount of light received by the emitter. These detectors can work well for black smoke but are less sensitive to gray smoke. Additionally, such detectors typically are not within a chamber, as they have an emitter and a receiver spaced at a substantial distance, such as one meter or across a room, whereas smoke detector chambers are preferably located within a compact housing. Another exemplary type of detector are indirect or reflected detectors, commonly called scatter detectors, which typically have an emitter and receiver positioned on non-collinear axes, such that light from the emitter does not shine directly onto the receiver. Smoke particles in the test atmosphere reflect or scatter light from the emitter into the receiver.

Smoke detectors typically use solid-state optical receivers such as photodiodes due to their low cost, small size, low power requirements, and ruggedness. One difficulty with solid-state receivers is their sensitivity to temperature. Additional circuitry that increases photo emitter current with increasing temperature partially compensates for temperature effects. Typical detectors also require complicated control electronics to detect the light level including analog amplifiers, filters, comparators, and the like. These components may be expensive if precision is required, may require adjustment when the smoke detector is manufactured, and may exhibit parameter value drift over time.

Further, detection systems, which include several such smoke detectors, typically only detect smoke. Thus, such a

detection system generally needs to include additional detectors to detect other particles besides smoke particles. However, the additional detectors typically result in an additional device in the system that has to be mounted on a building structure (e.g., a wall or ceiling) in addition to the smoke detector. Generally, the smoke detector and additional detector are not in communication with each other, such that if both detectors are emitting a noise based upon the detected particle, the emitted noises are emitted independent of one another.

SUMMARY

An object of the present invention is to provide a Bluetooth/WiFi bridge for a dwelling that provides an inexpensive way to converting existing dwelling alarms into intelligent alarms.

Another object of the present invention is to provide a Bluetooth/WiFi bridge for a dwelling that can be utilized with a plurality of different types of alarms from different manufacturers.

Yet another object of the present invention is to provide a Bluetooth/WiFi bridge for a dwelling that allows for a reassessment of an alarm, and a checking of an alarm sound.

A further object of the present invention is to provide a Bluetooth/WiFi bridge for a dwelling that enables any low power devices to communicate to the internet through the bridge.

Still a further object of the present invention is to provide a Bluetooth/WiFi bridge for a dwelling that enables a door lock to communicate its status through the internet without a user's phone being within RF range.

Another object of the present invention is to provide a Bluetooth/WiFi bridge for a dwelling that allows for detection of intrusion and potential high temperature conditions such as a fire condition.

Yet another object of the present invention is to provide a Bluetooth/WiFi bridge for a dwelling that puts a radio in every alarm in the dwelling.

These and other objects of the present invention are provided in a Bluetooth/WiFi bridge that includes a computing device in an interior of a dwelling with an internet-facing radio, and a second radio communicating with one or more non-internet-connected devices. The computing device provides for coordination of information flow between the two radios. The computing device is configured to enable the two radios to communicate and take incoming and outgoing information from one radio into a format that the other radio can transmit and receive. An audio sensor is configured to receive a sound from the one or more non-internet connected devices. The audio sensor is coupled to a logic circuit in the computing device. The internet facing radio is configured to communicate through a router to the internet and the non-internet devices connect to the internet via one of the radios through the computing device through the internet facing radio through the router to the internet, with the bridge communicating with a data center.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1(a) illustrates one embodiment of BLE/WiFi Bridge with audio sensors for the at least partial analysis of a sound from a detector in a dwelling.

FIG. 1(b) is an exploded view of a mounting assembly of an intelligent door lock device that can be used with the present invention and illustrates various embodiments of a positioning sensing device coupled to a drive shaft.

FIG. 1(c) illustrates one embodiment of a door lock device that can be used for retrofitting with an embodiment of an intelligent door lock device of the present invention.

FIG. 1(d) illustrates coupling of a positioning sensing device with a drive shaft of a door lock device.

FIG. 1(e) illustrates one embodiment of an intelligent door lock system of the present invention with an off-center drive.

FIG. 1(f) illustrates a wireless bridge that can be used in one embodiment of the present invention.

FIG. 1(g) illustrates one embodiment of elements coupled to a circuit in one embodiment of the present invention, including a haptic device.

FIGS. 2(a)-(c) illustrate embodiments of front and back surfaces of a main circuit that can be used and included in the intelligent door lock device of the present invention.

FIGS. 2(d)-(f) illustrate an embodiment of non-wire, direct connection between PCBAs in one embodiment of the present invention, with position of a PCBA in intelligent door lock device.

FIGS. 3(a)-(d) illustrate embodiments of LED lighting that can be used with the present invention.

FIGS. 4(a)-(d) illustrate one embodiment of a faceplate and views of a housing that can be used with the present invention.

FIGS. 5(a) and (b) illustrate the rotation range, with a minimized slot length of a faceplate lock that can be used in one embodiment of the present invention.

FIGS. 6(a) and (b) illustrate hook slots that can be used with the present invention.

FIGS. 7(a) through (e) illustrate one embodiment of a mount, with attachment to the mounting plate that can be used with the present invention.

FIGS. 8(a)-(b) illustrate embodiments of the present invention where magnets are utilized.

FIGS. 9(a)-(e) illustrate embodiments of the present invention with wing latches.

FIGS. 10(a)-(c) and FIGS. 11(a)-(d) illustrate further details of wing latching that is used in certain embodiments of the present invention.

FIGS. 12(a)-(d) illustrate embodiments of battery contacts that can be used with the present invention.

FIGS. 13(a) and (b) illustrate embodiments of a motor and gears in one embodiment of the present invention.

FIG. 14 illustrates an embodiment of the plurality of motion transfer device, including but not limited to gears, used in one embodiment of the present invention.

FIGS. 15(a)-(b) illustrate an embodiment of a speaker mounting.

FIGS. 15(c)-(d) illustrate an embodiment of an accelerometer FPC service loop.

FIG. 16 illustrates one embodiment of a back-end associated with the intelligent door lock system.

FIG. 17 is a diagram illustrating an implementation of an intelligent door lock system.

FIGS. 18(a) and (b) illustrate one embodiment of the present invention with a front view and a back view of a door with a bolt and an intelligent door lock system.

FIG. 19 illustrates more details of an embodiment of an intelligent door lock system of the present invention.

FIG. 20 illustrates one embodiment of the present invention showing a set of interactions between an intelligent door lock system, a mobile or computer and an intelligent door lock system back-end.

FIG. 21(a)-21(g) are examples of a user interface for an owner of a building that has an intelligent door lock system in one embodiment of the present invention.

FIGS. 22(a)-22(e) are examples of a user interface for a guest of an owner of a building that has an intelligent door lock system in one embodiment of the present invention.

FIGS. 23(a) and (b) illustrate one embodiment of an intelligent door lock system with an empty extension and extension gear adapters.

FIG. 24 illustrates one embodiment of a mobile device that is used with the intelligent door lock system.

FIG. 25 is an exemplary block diagram of a system employing embodiments of the present invention;

FIG. 26 is an exemplary block diagram of the analysis filter bank module in an exemplary embodiment of the present invention;

FIG. 27 illustrates a filter of the analysis filter bank module, according to one embodiment;

FIG. 28 illustrates for every six (6) sub-bands a log display of magnitude and phase of the sub-band transfer function;

FIG. 29 illustrates for every six (6) stages a log display of magnitude and phase of the accumulated filter transfer functions;

FIG. 30 illustrates the operation of the exemplary reconstruction module;

FIG. 31 illustrates a graphical representation of an exemplary reconstruction of the audio signal; and

FIG. 32 is a flowchart of an exemplary method for reconstructing an audio signal.

DETAILED DESCRIPTION

As used herein, the term engine refers to software, firmware, hardware, or other component that can be used to effectuate a purpose. The engine will typically include software instructions that are stored in non-volatile memory (also referred to as secondary memory). When the software instructions are executed, at least a subset of the software instructions can be loaded into memory (also referred to as primary memory) by a processor. The processor then executes the software instructions in memory. The processor may be a shared processor, a dedicated processor, or a combination of shared or dedicated processors. A typical program will include calls to hardware components (such as I/O devices), which typically requires the execution of drivers. The drivers may or may not be considered part of the engine, but the distinction is not critical.

As used herein, the term database is used broadly to include any known or convenient means for storing data, whether centralized or distributed, relational or otherwise.

As used herein a mobile device includes, but is not limited to, a cell phone, such as apple's iPhone®, other portable electronic devices, such as apple's iPod Touches®, apple's iPads®, and mobile devices based on Google's Android® operating system, and any other portable electronic device that includes software, firmware, hardware, or a combination thereof that is capable of at least receiving the signal, decoding if needed, exchanging information with a server to verify information. typical components of mobile device may include but are not limited to persistent memories like flash rom, random access memory like sram, a camera, a battery, led driver, a display, a cellular antenna, a speaker, a Bluetooth® circuit, and wifi circuitry, where the persistent memory may contain programs, applications, and/or an operating system for the mobile device. a mobile device can be a key fob a key fob which can be a type of security token which is a small hardware device with built in authentication mechanisms. It is used to manage and secure access to network services, data, provides access, communicates with door systems to open and close doors and the like.

As used herein, the term "computer" or "mobile device or computing device" is a general purpose device that can be programmed to carry out a finite set of arithmetic or logical operations. Since a sequence of operations can be readily changed, the computer can solve more than one kind of problem. A computer can include of at least one processing element, typically a central processing unit (CPU) and some form of memory. The processing element carries out arithmetic and logic operations, and a sequencing and control unit that can change the order of operations based on stored information. Peripheral devices allow information to be retrieved from an external source, and the result of operations saved and retrieved.

As used herein, the term "internet" is a global system of interconnected computer networks that use the standard internet protocol suite (TCP/IP) to serve billions of users worldwide. it is a network of networks that consists of millions of private, public, academic, business, and government networks, of local to global scope, that are linked by a broad array of electronic, wireless and optical networking technologies. The internet carries an extensive range of information resources and services, such as the inter-linked hypertext documents of the world-wide web (www) and the infrastructure to support email. The communications infrastructure of the internet consists of its hardware components and a system of software layers that control various aspects of the architecture, and can also include a mobile device network, e.g., a cellular network.

As used herein, the term "extranet" is a computer network that allows controlled access from the outside. An extranet can be an extension of an organization's intranet that is extended to users outside the organization that can be partners, vendors, and suppliers, in isolation from all other internet users. An extranet can be an intranet mapped onto the public internet or some other transmission system not accessible to the general public, but managed by more than one company's administrator(s). Examples of extranet-style networks include but are not limited to:

LANs or WANS belonging to multiple organizations and interconnected and accessed using remote dial-up

LANs OR WANS belonging to multiple organizations and interconnected and accessed using dedicated lines

Virtual private network (VPN) that is comprised of lans or wans belonging to multiple organizations, and that extends usage to remote users using special "tunneling" software that creates a secure, usually encrypted network connection over public lines, sometimes via an isp.

As used herein, the term "intranet" is a network that is owned by a single organization that controls its security policies and network management. Examples of intranets include but are not limited to:

ALAN

A wide-area network (WAN) that is comprised of alan that extends usage to remote employees with dial-up access

A WAN that is comprised of interconnected LANs using dedicated communication lines

A Virtual Private Network (VPN) that is comprised of a LAN or LAN that extends usage to remote employees or networks using special "tunneling" software that creates a secure, usually encrypted connection over public lines, sometimes via an internet service provider (ISP).

For purposes of the present invention, the internet, extranets and intranets collectively are referred to as ("Network Systems").

For purposes of the present invention a "Data Center" is a facility used to house computer systems and associated components, such as telecommunications and storage systems. It

generally includes redundant or backup power supplies, redundant data communications connections, environmental controls (e.g., air conditioning, fire suppression) and various security devices. Large data centers are industrial scale operations using as much electricity as a small town and sometimes are a significant source of air pollution in the form of diesel exhaust.

In one embodiment of the present invention, illustrated in FIG. 1(f), a Bluetooth/WiFi bridge 10(b) is provided that includes, a computing device in an interior of a dwelling 14(a) with an internet-facing radio 16(a), and a second radio 18 communicating with one or more non-internet-connected devices 20. In one embodiment the computing device is configured to connect non-internet-connected devices to the internet.

In one embodiment the computing device provides for coordination of information flow between the two radios 16(a) and 18. The computing device is configured to enable the two radios, 16(a) and 18 to communicate and take incoming and outgoing information from one radio into a format that the other radio can transmit and receive. An audio sensor 22(a), FIG. 1(g), is configured to receive a sound from the one or more non-internet connected devices. The audio sensor 22(a) is coupled to a logic circuit in the computing device. The internet facing radio 16(a) is configured to communicate through a router 39 to the internet and the non-internet devices 20 connect to the internet via one of the radios 16(a), 18 through the computing device through the internet facing radio 16(a) through a router 39 to the internet, with the bridge 10(b) communicating with a data center 28.

In one embodiment the internet facing radio 16(a) is configured to communicate through the router 39 to the Network Systems. The non-internet devices 20 connect to Network Systems, via the computing device, with the bridge 10(b) communicating with a data center 28.

The computing device provides for coordination of information flow between the two radios 16(a) and 18. Because most radios speak in different frequencies or protocols, packet sizes, and the like, the computing device enables the two radios 16(a) and 18 to communicate, takes incoming and outgoing information from one radio into the proper format that the other radio can transmit and receive. In one embodiment the computing device makes the first and second radios 16(a) and 18 the same thing.

An audio sensor 22(a) is configured to receive a sound from the one or more non-internet connected devices. The audio sensor 22(a) is coupled to a logic circuit 12(a) in the computing device.

The internet facing radio 16(a) is configured to communicate through the router 24 to the internet. The non-internet devices connect to the internet via one of the radios 16(a), 18 through the computing device through the internet facing radio 16(a) through the router 24 to the internet, with the bridge 10(b) communicating with the data center 28.

In one embodiment the computing device is of a form factor similar to an AC-to-DC power adaptor. As a non-limiting example the form factor is configured to provide that it can be grasped by a single hand and plugged into a wall without handling electrical cables and wires.

In one embodiment the computing device is a wall wart, and equivalent element, which is a power adapter that contains the plug for a wall outlet.

In one embodiment the internet-facing radio and the second radio transmit radio waves for communication purposes.

In one embodiment the non-internet device is a low power device. As a non-limiting example a low power device is one

that uses battery power. As a non-limiting example this can be from 40 mW hours to 40 W hours.

In one embodiment the bridge 10(b) provides at least a partial analysis of an alarm sound received from an alarm that is in the interior of the dwelling. It will be appreciated that a dwelling can be any structure, office building, and the like.

In one embodiment the bridge 10(b) provides at least a partial probability analysis of an alarm sound that is in the interior of a dwelling where the bridge 10(b) is located, where the probably is directed to sound of interest that is indicative of an adverse condition in the interior of the dwelling. In another embodiment a human in the interior of the dwelling does the analysis of the sound. In another embodiment a back-end from a third party receives a message from a call center for further analysis.

In one embodiment on the plug side a frequency and general pattern of the sound is determined. There is a frequency distribution, e.g. which frequency with side bands is associated with the sound. If this matches that of an alarm then it is forwarded by wireless communication to the data center 28.

The data center 28 has banks of sound signatures. The call center matches the sound signatures with the sound and looks for a match. When there is a match the data center 28 can do a variety of things, including but not limited to, notifying the user at the dwelling, notifying an emergency response center or team, and notify a human who is human being, not at the dwelling, e.g., at a third party site, who can be a better judge.

When the sound is substantially or an exact match at the dwelling, e.g., via the bridge 10(b), there are still background noises and therefore it is preferred to have the sound analyzed at the data center 28, FIG. 1(g), and if there is a very good match, or even an exact match, the data center 28 can take the actions mentioned above, including notifying a third party who can do further human analysis of the sound.

As non-limiting examples, the adverse condition can be an alarm from a smoke detector, the detection of other particulate matter, detection of carbon monoxide, detection of elevated temperatures, the detection of a breakage into a dwelling, entrance of an intruder, and the like.

In one embodiment the adverse condition is a detection of an intrusion into the dwelling.

In one embodiment the bridge 10(b) is in communication with the data center 28.

In various embodiments the bridge 10(b) (i) provides an inexpensive way to converting existing dwelling alarms into intelligent alarms; (ii) can be utilized with a plurality of different types of alarms from different manufacturers; (iii) allows for an reassessment of an alarm, and a checking of an alarm sound, (iv) enables any low power devices to communicate to the internet through the bridge; (v) enables a door lock to communicate its status through the internet without a user's phone being within RF range; (vi) allows for detection of intrusion and potential high temperature conditions such as a fire condition; (vii) puts a radio in every alarm in the dwelling; and the like.

In one embodiment the data center 28 includes a filter 30 for further analysis of the adverse condition.

In one embodiment the data center 28 provides further analysis of the alarm sound for the adverse condition.

In one embodiment the data center 28 notifies the user of the alarm sound.

In one embodiment the data center 28 notifies the user of the alarm sound and gives the user the option to listen to a snippet of the sound.

In one embodiment the data center 28 first routes the sound to a manned operation center for confirmation before notifying the user

In one embodiment the bridge **10(b)** tries to figure it out but does not make a final determination about the sound.

In one embodiment the data center **28** makes a final determination about the alarm sound.

In one embodiment the data center **28** provides notice to the user regarding the alarm sound, and the user uses this information to determine if a call should be made regarding the alarm sound.

The bridge **10(b)** provides a bridge between the non-internet devices to Network Systems by communicating through a router connected to the internet.

In one embodiment the user makes a final a determination relative to an interpretation of the alarm sound.

In one embodiment the bridge **10(b)** acts as a filter and it filters sounds of interest to the data center for further analysis.

In one embodiment the bridge **10(b)** is coupled to an intelligent lock system.

Referring now to FIG. **1(a)**, one embodiment of an intelligent door lock system **10(a)** is illustrated, as more fully described hereafter.

In one embodiment the door lock system **10(a)** includes a vibration sensing device configured to be coupled intelligent lock system **10(a)**. In one embodiment the vibration sensing device senses knocking on the door and locks or unlocks the door. In one embodiment the vibration sensing device is not included as part of the actual intelligent door lock system. In one embodiment the vibration sensing device is coupled to the drive shaft **14(b)**. It will be appreciated that the vibration sensing device can be coupled to other elements of the intelligent door lock system **10(a)**. The vibration sensing device detects vibration or knocking applied to a door that is used to unlock or lock the intelligent door lock system **10(a)**. This occurs following programming the intelligent door lock system **10(a)**. The programming includes a user's vibration code/pattern, and the like. Additionally, a user can give a third person a knock code/pattern to unlock the intelligent door lock system of the door. The knocking is one that is recognized as having been defined by a user of the door lock system **10(a)** as a means to unlock the door. The knocking can have a variety of different patterns, tempos, duration, intensity and the like.

The vibration sensing device **16(b)** detects oscillatory motion resulting from the application of oscillatory or varying forces to a structure. Oscillatory motion reverses direction. The oscillation may be continuous during some time period of interest or it may be intermittent. It may be periodic or nonperiodic, i.e., it may or may not exhibit a regular period of repetition. The nature of the oscillation depends on the nature of the force driving it and on the structure being driven.

Motion is a vector quantity, exhibiting a direction as well as a magnitude. The direction of vibration is usually described in terms of some arbitrary coordinate system (typically Cartesian or orthogonal) whose directions are called axes. The origin for the orthogonal coordinate system of axes is arbitrarily defined at some convenient location.

In one embodiment, the vibratory responses of structures can be modeled as single-degree-of-freedom spring mass systems, and many vibration sensors use a spring mass system as the mechanical part of their transduction mechanism.

In one embodiment the vibration sensing device can measure displacement, velocity, acceleration, and the like.

A variety of different vibration sensing devices can be utilized, including but not limited to accelerometers, optical devices, electromagnetic and capacitive sensors, contact devices, transducers, displacement transducers, piezoelectric sensors, piezoresistive devices, variable capacitance, servo

devices, audio devices where transfer of the vibration can be gas, liquid or solid, including but not limited to microphones, geo-phones, and the like.

Suitable accelerometers include but are not limited to: Piezoelectric (PE); high-impedance output; Integral electronics piezoelectric (IEPE); low-impedance output Piezoresistive (PR); silicon strain gauge sensor Variable capacitance (VC); low-level, low-frequency Servo force balance; and the like.

The vibration sensing device can be in communication with an intelligent door lock system back-end **68**, via Network Systems, as more fully described hereafter.

In one embodiment, the intelligent door lock system **10(a)** is configured to be coupled to a structure door **12**, including but not limited to a house, building and the like, window, locked cabinet, storage box, bike, automobile door or window, computer locks, vehicle doors or windows, vehicle storage compartments, and the like. In one embodiment, the intelligent door lock system **10(a)** is coupled to an existing drive shaft **14(b)** of a lock device **22(b)** already installed and is retrofitted to all or a portion of the lock device **22(b)**, which includes a bolt/lock **24**. In another embodiment, the intelligent door lock system **10(a)** is attached to a door **12**, and the like, that does not have a pre-existing lock device. FIG. **1(b)** illustrates door lock elements that can be at an existing door, to provide for the mounting of the intelligent door lock system **10(a)** with an existing lock device **22(b)**.

FIGS. **1(b)** and **1(g)** illustrate one embodiment of a lock device **22(b)** that can be pre-existing at a door **12** with the intelligent door lock system **10(a)** retrofitted to it. Components of the lock device **22(b)** may be included with the intelligent door lock system **10(a)**, as more fully discussed hereafter.

In one embodiment, the intelligent door lock system **10(a)** includes a positioning sensing device **16(c)**, a motor **38**, an engine/processor **36** with a memory and one or more wireless communication devices **40**, see FIG. **1(f)**, coupled to a circuit **18**. The motor **38** converts any form of energy into mechanical energy. As a non-limiting example, three more four wireless communications devices are in communication with circuit **18**. In one embodiment the vibration sensing device can be included with the positioning sensing device.

In one embodiment, the intelligent door lock system **10(a)** is provided with the position sensing device **16(c)** configured to be coupled to the drive shaft **14(b)** of the lock device **22(b)**. The position sensing device **16(c)** senses position of the drive shaft **14** and assists in locking and unlocking the bolt/lock **24** of the lock device **22(b)**. The engine **36** is provided with a memory. The engine **36** is coupled to the positioning sensing device **16(c)**. A circuit **18** is coupled to the engine **36** and an energy source **50** is coupled to the circuit. A device **38** converts energy into mechanical energy and is coupled to the circuit **18**, positioning sensing device **16(c)** and the drive shaft **14(b)**. Device **38** is coupled to the energy source **50** to receive energy from the energy source **50**, which can be via the circuit **18**.

In one embodiment, the intelligent door lock system **10(a)** includes any or all of the following, a face plate **20**, ring **32**, latches such as wing latches **37**, adapters **28** coupled to a drive shaft **14(b)**, one or more mounting plates **26**, a back plate **30**, a power sensing device **46**, energy sources **50**, including but not limited to batteries **50**, and the like.

In one embodiment (see FIG. **1(c)**), the intelligent door lock system **10(a)** retrofits to an existing lock device **22(b)** already installed and in place at a door **12**, and the like. The existing lock device **22(b)** can include one or more of the following elements, drive shaft **14(b)**, a lock device **22** with the bolt/lock

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24, a mounting plate 26, one or more adapters 28 for different lock devices 22(b), a back plate 30, a plurality of motion transfer devices 34, including but not limited to, gears 34, and the like.

In one embodiment, the memory of engine/processor 36 includes states of the door 12. The states are whether the door 12 is a left handed mounted door, or a right handed mounted door, e.g., opens from a left side or a right side relative to a door frame. The states are used with the position sensing device 16(c) to determine via the engine/processor 36 if the lock device 22(b) is locked or unlocked.

In one embodiment, the engine/processor 36 with the circuit 18 regulates the amount of energy that is provided from energy source 50 to the motor 38. This thermally protects the motor 38 from receiving too much energy and ensures that the motor 38 does not overheat or become taxed.

FIG. 1(d) illustrates various embodiments of the positioning sensing device 16(c) coupled to the drive shaft 14(b).

A variety of position sensing devices 16(c) can be used, including but not limited to, accelerometers, optical encoders, magnetic encoders, mechanical encoders, Hall Effect sensors, potentiometers, contacts with ticks, optical camera encoders, and the like.

As a non-limiting example, an accelerometer 16(c), well known to those skilled in the art, detects acceleration. The accelerometer 16(c) provides a voltage output that is proportional to a detected acceleration. Suitable accelerometers 16(c) are disclosed in, U.S. Pat. No. 8,347,720, U.S. Pat. No. 8,544,326, U.S. Pat. No. 8,542,189, U.S. Pat. No. 8,522,596, EP0486657B1, EP 2428774 A1, incorporated herein by reference.

In one embodiment, the position sensing device 16(c) is an accelerometer 16(c). Accelerometer 16(c) includes a flex circuit coupled to the accelerometer 16(c). The accelerometer reports X, Y, and X axis information to the engine/processor 36 of the drive shaft 14(b). The engine/processor 36 determines the orientation of the drive shaft 14(b), as well as door knocking, bolt/lock 24 position, door 12 close/open (action) sensing, manual key sensing, and the like, as more fully explained hereafter.

Suitable optical encoders are disclosed in U.S. Pat. No. 8,525,102, U.S. Pat. No. 8,351,789, and U.S. Pat. No. 8,476,577, incorporated herein by reference.

Suitable magnetic encoders are disclosed in U.S. Publication 20130063138, U.S. Pat. No. 8,405,387, EP2579002A1, EP2642252 A1, incorporated herein by reference.

Suitable mechanical encoders are disclosed in, U.S. Pat. No. 5,695,048, and EP2564165A2, incorporated herein by reference.

Suitable Hall Effect sensors are disclosed in, EP2454558B1 and EP0907068A1, incorporated herein by reference.

Suitable potentiometers are disclosed in, U.S. Pat. No. 2,680,177, EP1404021A3, CA2676196A1, incorporated herein by reference.

In various embodiments, the positioning sensing device 16(c) is coupled to the drive shaft 14(b) by a variety of means, including but not limited to the adapters 28. In one embodiment, the position sensing device 16(c) uses a single measurement, as defined herein, of drive shaft 14(b) position sensing which is used to determine movement in order the determine the location of the drive shaft 14(b) and the positioning sensing device 16(c). The exact position of the drive shaft 14(b) can be measured with another measurement without knowledge of any previous state. Single movement, which is one determination of position sensing, is the knowledge of whether the door 12 is locked, unlocked or in

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between. One advantage of the accelerator 16(c) is that one can determine position, leave if off, come back at a later time, and the accelerometer 16(c) will know its current position even if it has been moved since it has been turned off. It will always know its current position.

In one embodiment, the positioning sensing device 16(c) is directly coupled to the drive shaft 14(b), as illustrated in FIG. 1(d). Sensing position of the positioning sensing device 16(c) is tied to the movement of the drive shaft 14(b). In one embodiment with an accelerometer 16(c), the accelerometer 16(c) can detect X, Y and Z movements. Additional information is then obtained from the X, Y, and Z movements. In the X and Y axis, the position of the drive shaft 14(b) is determined; this is true even if the drive shaft 14(b) is in motion. The Z axis is used to detect a variety of things, including but not limited to, door 12 knocking, picking of the lock, break-in and unauthorized entry, door 12 open and closing motion. If a mobile device 201 is used to open or close, the processor 36 determines the lock state.

In one embodiment, the same positioning sensing device 16(c) is able to detect knocks by detecting motion of the door 12 in the Z axis. As a non-limiting example, position sensing is in the range of counter and clock wise rotation of up to 180 degrees for readings. The maximum rotation limit is limited by the position sensing device 16(c), and more particularly to the accelerometer cable. In one embodiment, the result is sub 10 resolution in position sensing. This provides a higher lifetime because sampling can be done at a slower rate, due to knowing the position after the position sensing device 16(c) has been turned off for a time period of no great 100 milliseconds. With the present invention, accuracy can be enhanced taking repeated measurements. With the present invention, the positioning sensing device 16(c), such as the accelerometer (c), does not need to consume additional power beyond what the knock sensing application already uses.

In one embodiment, the position sensing device 16(c) is positioned on the drive shaft 14(b), or on an element coupled to the drive shaft 14(b). In one embodiment, a position of the drive shaft 14(b) and power sensing device and/or a torque limited link 38 are known. When the position of the drive shaft 14(b) is known, it is used to detect if the bolt/lock 24 of a door lock device 22(b) is in a locked or unlocked position, as well as a depth of bolt/lock 24 travel of lock device 22(b), and the like. This includes but is not limited to if someone, who turned the bolt/lock 24 of lock device 22(b) from the inside using the ring 32, used the key to open the door 12, if the door 12 has been kicked down, attempts to pick the bolt/lock 24, bangs on the door 12, knocks on the door 12, opening and closing motions of the door 12 and the like. In various embodiments, the intelligent door lock system 10 can be interrogated via hardware, including but not limited to a key, a mobile device, a computer, key fob, key cards, personal fitness devices, such as Fitbit®, nike fuel, jawbone up, pedometers, smart watches, smart jewelry, car keys, smart glasses, including but not limited to Google Glass, and the like.

During a power up mode, the current position of the drive shaft 14(b) is known.

Real time position information of the drive shaft 14(b) is determined and the bolt/lock 24 of lock device 22(b) travels can be inferred from the position information of the drive shaft 14(b). The X axis is a direction along a width of the door 12, the Y axis is in a direction along a length of a door 12, and the Z axis is in a direction extending from a surface of the door 12.

In one embodiment, the accelerometer 16(c) is the knock sensor. Knocking can be sensed, as well as the number of

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times a door 12 is closed or opened, the physical swing of the door 12, and the motion the door 12 opening and closing. With the present invention, a determination is made as to whether or not someone successfully swung the door 12, if the door 12 was slammed, and the like. Additionally, by coupling the position sensing device 16(c) on the moveable drive shaft 14(b), or coupled to it, a variety of information is provided, including but not limited to, if the bolt/lock 24 is stored in the correct orientation, is the door 12 properly mounted and the like.

In one embodiment, a calibration step is performed to determine the amount of drive shaft 14(b) rotations to fully lock and unlock the bolt/lock 24 of lock device 22(b). The drive shaft 14(b) is rotated in a counter-counter direction until it can no longer rotate, and the same is then done in the clock-wise direction. These positions are then stored in the engine memory. Optionally, the force is also stored. A command is then received to rotate the drive shaft 14(b) to record the amount of rotation. This determines the correct amount of drive shaft 14(b) rotations to properly lock and unlock the lock device 22(b).

In another embodiment, the drive shaft 14(b) is rotated until it does not move anymore. This amount of rotation is then stored in the memory and used for locking and unlocking the lock device 22(b).

In another embodiment, the drive shaft 14(b) is rotated until it does not move anymore. However, this may not provide the answer as to full lock and unlock. It can provide information as to partial lock and unlock. Records from the memory are then consulted to see how the drive shaft 14(b) behaved in the past. At different intervals, the drive shaft 14(b) is rotated until it does not move anymore. This is then statistically analyzed to determine the amount of drive shaft 14(b) rotation for full locking and unlocking. This is then stored in the memory.

In one embodiment, the engine/processor 36 is coupled to at least one wireless communication device 40 that utilizes audio and RF communication to communicate with a wireless device, including but not limited to a mobile device/key fob 210, with the audio used to communicate a security key to the intelligent door lock system 10(a) from the wireless device 210 and the RF increases a wireless communication range to and from the at least one wireless communication device 40. In one embodiment, only one wireless communication device 40 is used for both audio and RF. In another embodiment, one wireless communication device 40 is used for audio, and a second wireless communication device 40 is used for RF. In one embodiment, the bolt/lock 24 is included in the intelligent door lock system 10(a). In one embodiment, the audio communications initial set up information is from a mobile device/key fob 210 to the intelligent door lock system 10(a), and includes at least one of, SSID WiFi, password WiFi, a Bluetooth key, a security key and door configurations.

In one embodiment, an audio signal processor unit includes an audio receiver, a primary amplifier circuit, a secondary amplifier circuit, a current amplifier circuit, a wave detection circuit, a switch circuit and a regulator circuit. In one embodiment, the audio receiver of each said audio signal processor unit is a capacitive microphone. In one embodiment, the switch circuit of each audio signal processor unit is selected from one of a transistor and a diode. In one embodiment, the regulator circuit of each audio signal processor unit is a variable resistor. In one embodiment, the audio mixer unit includes a left channel mixer and a right channel mixer. In one embodiment, the amplifier unit includes a left audio amplifier and a right audio amplifier. In one embodiment, the Bluetooth device includes a sound volume control circuit with an

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antenna, a Bluetooth microphone and a variable resistor, and is electrically coupled with the left channel mixer and right channel mixer of said audio mixer unit. Additional details are in U.S. Publication US20130064378 A1, incorporated fully herein by reference.

In one embodiment, the faceplate 20 and/or ring 32 is electrically isolated from the circuit 18 and does not become part of circuit 18. This allows transmission of RF energy through the faceplate 20. In various embodiments, the faceplate and/or ring are made of materials that provide for electrical isolation. In various embodiments, the faceplate 20, and/or the ring 32 are at ground. As non-limiting examples, (i) the faceplate 20 can be grounded and in non-contact with the ring 32, (ii) the faceplate 20 and the ring 32 are in non-contact with the ring 32 grounded, (iii) the faceplate 20 and the ring can be coupled, and the ring 32 and the faceplate 20 are all electrically isolated from the circuit 18. In one embodiment, the ring 32 is the outer enclosure to the faceplate 20, and the bolt/lock 24 and lock device 22(b) is at least partially positioned in an interior defined by the ring 32 and the faceplate 20.

In one embodiment, the lock device 22(b) has an off center drive mechanism relative to the outer periphery that allows up to R displacements from a center of rotation of the bolt/lock 24 of lock device 22(b), where R is a radius of the bolt/lock 24, 0.75 R displacements, 0.5 R displacements, and the like, as illustrated in FIG. 1(e). The off center drive mechanism provides for application of mechanical energy to the lock device 22(b) and bolt/lock 24 off center relative to the outer periphery.

As illustrated in FIG. 1(f) in one embodiment, a wireless communication bridge 41, which can also be bridge 10(b) is coupled to a first wireless communication device 40 that communicates with Network Systems via a device, including but not limited to a router 39, a 3G device, a 4G device, and the like, as well as mobile device 210. The wireless communication bridge 41 is also coupled to a second wireless communication device 40 that is coupled to the processor 38, circuit 18, positioning sensing device 16(c), motor 38 and the lock device 22(b) with bolt/lock 24, and provides for more local communication. The first wireless communication device 40 is in communication with the second wireless communication device 40 via bridge 41. The second wireless communication device 40 provides local communication with the elements of the intelligent door lock system 10(a). In one embodiment, the second communication device 40 is a Bluetooth device. In one embodiment, the wireless communication bridge 41 includes a third wireless communication device 40. In one embodiment, the wireless communication bridge 41 includes two wireless communication devices 40, e.g. third and fourth wireless communication devices 40. In one embodiment, the wireless communication bridge 41 includes a WiFi wireless communication device 40 and a Bluetooth wireless communication device 40.

FIG. 1(g) illustrates various elements that are coupled to the circuit 18 in one embodiment of the present invention.

In one embodiment of the present invention, a haptic device 49 is included to provide the user with haptic feedback for the intelligent door lock system 10(a), see FIG. 1(g). The haptic device is coupled to the circuit 18, the processor 38, and the like. In one embodiment, the haptic device provides a visual indication that the bolt/lock 24 of lock device 22(b) has reached a final position. In another embodiment, the haptic device 49 provides feedback to the user that the bolt/lock 24 of lock device 22(b) has reached a home open position verses a final position so the user does not over-torque. A suitable

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haptic device **49** is disclosed in U.S. Publication No. 20120319827 A1, incorporated herein by reference.

In one embodiment, the wing latches **37** are used to secure the intelligent door lock system **10(a)** to a mounting plate **26** coupled to the door **12**. In one embodiment, the wing latches **37** secure the intelligent door lock system **10(a)** to a mounting plate **26** coupled to a door **12** without additional tools other than the wing latches **37**.

FIG. **1(g)** illustrates one embodiment of circuit **18**, as well as elements that includes as part of circuit **18**, or coupled to circuit **18**, as discussed above.

FIGS. **2(a)-(c)** illustrate front and back views of one embodiment of circuit **18**, and the positioning of circuit **18** in the intelligent door lock system **10(a)**. FIGS. **2(d)-(e)** illustrate an embodiment of non-wire, direct connection between PCBAs. FIG. **2(e)** shows the relative positioning of a PCBA in the intelligent door lock device **10(a)**.

In one embodiment, see FIG. **1(g)**, the main circuit **18** is coupled to, the engine **36** with a processor and memory, the motor **38**, wireless communication device **40** such as a WiFi device including but not limited to a Bluetooth device with an antenna, position sensing device **16(c)**, speaker (microphone) **17**, temperature sensor **42**, battery voltage sensor **44**, current sensor or power sensor **46** that determines how hard the motor **38** is working, a protection circuit to protect the motor from overheating, an LED array **48** that reports status and one or more batteries **50** that power circuit **18**, see FIG. **1(g)**.

The power sensor **46** monitors the amount of current that goes to the motor **38** and this information is received and processed by the engine/processor **36** with memory and is coupled to the circuit **18**. The amount of current going to the motor **38** is used to determine the amount of friction experienced by door **12** and/or lock device **22(b)** with lock/bolt **24** in opening and/or closing, as applied by the intelligent door lock system **10(a)** and the positioning sensing device **16(c)** to the drive shaft **14(b)**. The circuit **18** and engine/processor **36** can provide for an adjustment of current. The engine/processor **36** can provide information regarding the door and friction to the user of the door **12**.

FIGS. **3(a)-(b)** illustrate embodiments of LED **48** lighting that can include diffusers, a plurality of LED patterns point upward, inward, and outward and a combination of all three. In one embodiment two control PCDs are provide to compare side by side. Each LED **48** can be independently addressable to provide for maximization of light with the fewest LEOs **48**. In one embodiment, an air gap is provided.

FIGS. **4(a)-(d)**, illustrate one embodiment of a faceplate **20** and views of the housing **32** and faceplate **20**.

FIGS. **5(a)** and **(b)** illustrate the rotation range of the ring **32**, with a minimized slot length of a bolt/lock **24** of lock device **22(b)** in one embodiment of the present invention. In one embodiment, there is a 1:1 relationship of ring **32** and shaft rotation. In other embodiments, the ratio can change. This can be achieved with gearing. In various embodiments, the bolt/lock **24** and/or lock device **22(b)** can have a rotation of 20-5 and less turns clockwise or counter-clockwise in order to open the door **12**. Some lock devices **22(b)** require multiple turns.

FIGS. **6(a)** and **(b)**, with front and back views, illustrate hook slots **52** that can be used with the present invention.

FIGS. **7(a)** through **(f)** illustrate an embodiment of a mount **54**, with attachment to the mounting plate **26**. Screws **56** are captured in the housing **58**, and/or ring **32** and accessed through a battery cavity. A user can open holes for access and replace the screws **56**. In one embodiment, the screws extend through the mounting plate **26** into a door hole. In one embodiment, a height of the mounting plate **26** is minimized.

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During assembly, the lock device **22(b)** is held in place, FIG. **7(c)**, temporarily by a top lip, FIG. **7(d)** and the lock drive shaft **14(b)**.

FIGS. **8(a)-(b)** illustrate embodiments where magnets **60** are utilized. The magnet **60** locations are illustrated as are the tooled recesses from the top and side. In one embodiment, the magnets **60** are distanced by ranges of 1-100 mm, 3-90, 5-80 mm apart and the like.

FIGS. **9(a)-(e)** illustrate embodiments of the present invention with wing latches **36**. The wing latches **36** allow for movement of the lock device **22(b)** with bolt/lock **24** towards its final position, in a Z-axis direction towards the door **12**. Once the lock device **22(b)** with bolt/lock **24** is in a final position, the wing latches **36** allows for the secure mounting without external tools. The wing latches **36** do the mounting. Wing latches **36** enable mounting of the lock device **22(b)** and bolt/lock **24** with use of only the Z axis direction only, and X and Y directionality are not needed for the mounting.

In one embodiment, a lead in ramp, FIG. **9(e)** is used to pull the elements together.

FIGS. **10(a)-(c)** and FIGS. **11(a)-(d)** illustrate further details of wing latching.

FIGS. **12(a)-(d)** illustrate embodiments of battery contacts **64**.

FIGS. **13(a)** and **(b)** illustrate embodiments of motor **38** and one or more gears **34**, with a gearbox **66**. In one embodiment, a first gear **34** in sequence takes a large load if suddenly stopped while running.

FIG. **14** illustrates an embodiment of a plurality of motion transfer devices such as gears **34**. There can be come backlash in a gear train as a result of fits and tolerances. There can also be play between adapters **28** and lock drive shafts **14(b)**. This can produce play in an out gearbox **66** ring. This can be mitigated with a detent that located the outer ring.

The intelligent door lock system **10(a)** can be in communication with an intelligent door lock system back-end **68**, via Network Systems, as more fully described hereafter.

In one embodiment, the flex circuit **18**, which has an out-of plane deflection of at least 1 degree, includes a position sensor **47** that include a detector connector, Bluetooth circuit, and associated power points, as well as other elements.

In one embodiment, the intelligent door lock system **10(a)** can use incremental data transfer via Network Systems, including but not limited to BLUETOOTH® and the like. The intelligent door lock system **10(a)** can transmit data through the inductive coupling for wireless charging. The user is also able to change the frequency of data transmission.

In one embodiment, the intelligent door lock system **10(a)** can engage in intelligent switching between incremental and full syncing of data based on available communication routes. As a non-limiting example, this can be via cellular networks, WiFi, BLUETOOTH® and the like.

In one embodiment, the intelligent door lock system **10(a)** can receive firmware and software updates from the intelligent lock system back-end **68**.

In one embodiment, the intelligent door lock system **10(a)** produces an output that can be received by an amplifier, and decoded by an I/O decoder to determine I/O logic levels, as well as, both clock and data information. Many such methods are available including ratio encoding, Manchester encoding, Non-Return to Zero (NRZ) encoding, or the like; alternatively, a UART type approach can be used. Once so converted, clock and data signals containing the information bits are passed to a memory at the intelligent door lock system **10(a)** or intelligent door lock system back-end **68**.

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In one embodiment, the intelligent door lock system **10(a)**, or associated back-end **68**, can include a repeatable pseudo randomization algorithm in ROM or in ASIC logic.

FIGS. **15(a)-(b)** illustrate an embodiment of a speaker **17** and speaker mounting **70**.

FIGS. **15(c)-(d)** illustrate one embodiment of an accelerometer FPC service loop.

As illustrated in FIG. **16**, the intelligent door lock system back-end **68** can include one or more receivers **74**, one or more engines **76**, with one or more processors **78**, coupled to conditioning electronics **80**, one or more filters **82**, one or more communication interfaces **84**, one or more amplifiers **86**, one or more databases **88**, logic resources **90** and the like.

The back-end **68** knows that an intelligent door lock system **10(a)** is with a user, and includes a database with the user's account information. The back-end **68** knows if the user is registered or not. When the intelligent door lock system **10(a)** is powered up, the back-end **68** associated that intelligent door lock system **10(a)** with the user.

The conditioning electronics **80** can provide signal conditioning, including but not limited to amplification, filtering, converting, range matching, isolation and any other processes required to make sensor output suitable for processing after conditioning. The conditioning electronics can provide for, DC voltage and current, AC voltage and current, frequency and electric charge. Signal inputs accepted by signal conditioners include DC voltage and current, AC voltage and current, frequency and electric charge. Outputs for signal conditioning electronics can be voltage, current, frequency, timer or counter, relay, resistance or potentiometer, and other specialized output.

In one embodiment, the one or more processors **78**, can include a memory, such as a read only memory, used to store instructions that the processor may fetch in executing its program, a random access memory (RAM) used by the processor **78** to store information and a master clock. The one or more processors **78** can be controlled by a master clock that provides a master timing signal used to sequence the one or more processors **78** through internal states in their execution of each processed instruction. In one embodiment, the one or more processors **78** can be low power devices, such as CMOS, as is the necessary logic used to implement the processor design. Information received from the signals can be stored in memory.

In one embodiment, electronics **92** are provided for use in intelligent door system **10(a)** analysis of data transmitted via System Networks. The electronics **92** can include an evaluation device **94** that provides for comparisons with previously stored intelligent door system **10(a)** information.

Signal filtering is used when the entire signal frequency spectrum contains valid data. Filtering is the most common signal conditioning function, as usually not all the signal frequency spectrum contains valid data.

Signal amplification performs two important functions: increases the resolution of the inputted signal, and increases its signal-to-noise ratio.

Suitable amplifiers **86** include but are not limited to sample and hold amplifiers, peak detectors, log amplifiers, anti log amplifiers, instrumentation amplifiers, programmable gain amplifiers and the like.

Signal isolation can be used in order to pass the signal from to a measurement device without a physical connection. It can be used to isolate possible sources of signal perturbations.

In one embodiment, the intelligent door lock system back-end **68** can provide magnetic or optic isolation. Magnetic isolation transforms the signal from voltage to a magnetic field, allowing the signal to be transmitted without a physical

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connection (for example, using a transformer). Optic isolation takes an electronic signal and modulates it to a signal coded by light transmission (optical encoding), which is then used for input for the next stage of processing.

In one embodiment, the intelligent door lock system **10(a)** and/or the intelligent door lock system back-end **68** can include Artificial Intelligence (AI) or Machine Learning-grade algorithms for analysis. Examples of AI algorithms include Classifiers, Expert systems, case based reasoning, Bayesian networks, and Behavior based AI, Neural networks, Fuzzy systems, Evolutionary computation, and hybrid intelligent systems.

Information received or transmitted from the back-end **68** to the intelligent door system **10(a)** and mobile device **210** can use logic resources, such as AI and machine learning grade algorithms to provide reasoning, knowledge, planning, learning communication, and create actions.

In one embodiment, AI is used to process information from the intelligent door lock system **10(a)**, from mobile device **210**, and the like. The back-end **68** can compute scores associated with various risk variables involving the intelligent door lock system **10(a)**. These score can be compared to a minimum threshold from a database and an output created. Alerts can be provided to the intelligent door lock system **10(a)**, mobile device **210** and the like. The alert can provide a variety of options for the intelligent door lock system **10(a)** to take, categorizations of the received data from the mobile device **210**, the intelligent door lock system **10(a)**, and the like, can be created. A primary option can be created as well as secondary options.

In one embodiment, data associated with the intelligent door lock system **10(a)** is received. The data can then be pre-processed and an array of action options can be identified. Scores can be computed for the options. The scores can then be compared to a minimum threshold and to each other. A sorted list of the action options based on the comparison can be outputted to the intelligent door lock system **10(a)**, the mobile device **210** and the like. Selections can then be received indicating which options to pursue. Action can then be taken. If an update to the initial data is received, the back-end **68** can then return to the step of receiving data.

Urgent indicators can be determined and directed to the intelligent door lock system **10(a)**, including unlocking, locking and the like.

Data received by the intelligent door lock system **10(a)** and mobile device **210** can also be compared to third party data sources.

In data evaluation and decision making, algorithm files from a memory can be accessed specific to data and parameters received from the intelligent door lock system **10(a)** and mobile device **210**.

Scoring algorithms, protocols and routines can be run for the various received data and options. Resultant scores can then be normalized and weights assigned with likely outcomes.

The intelligent door lock system **10(a)** can be a new lock system mounted to a door **12**, with all or most of the elements listed above, or it can be retrofitted over an existing lock device **22(b)**.

To retrofit the intelligent door lock system **10(a)** with an existing lock system, the user makes sure that the existing lock device **22(b)** and bolt/lock **24** is installed right-side up. The existing thumb-turn is then removed. With some lock devices **22(b)**, additional mounting plates **26** need to be removed and the intelligent door lock system **10(a)** can include replacement screws **56** that are used. The correct mounting plate **26** is then selected. With the existing screws

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56 in the thumb-turn, the user sequentially aligns with 1 of 4 mounting plates 26 that are supplied or exist. This assists in determining the correct diameter and replace of the screws 56 required by the bolt/lock 24. The mounting plate 26 is then positioned. The correct adapter 28 is positioned in a center of the mounting plate 26 to assist in proper positioning. Caution is made to ensure that the adapter 28 does not rub the sides of the mounting plate 26 and the screws 56 are then tightened on the mounting plate 26. The intelligent door lock system bolt/lock 24 of lock device 22(b) is then attached. In one embodiment, this is achieved by pulling out side wing latches 36, sliding the lock device 22(b) and/or bolt/lock 24 over the adapter 28 and pin and then clamping down the wings 36 to the mounting plate 26. The faceplate is rotated to open the battery compartment and the battery tabs are then removed to allow use of the battery contacts 64. An outer metal ring 32 to lock and unlock the door 12 is then rotated. An app from mobile device 210 and/or key then brings the user through a pairing process.

A door 12 can be deformed, warped, and the like. It is desirable to provide a customer or user, information about the door, e.g., if it is deformed, out of alignment, if too much friction is applied when opening and closing, and the like.

As recited above, the current sensor 46 monitors the amount of current that goes to the motor 38 and this information is received and processed by the engine/processor 36 with memory and is coupled to the circuit 18. The amount of current going to the motor 38 is used to determine the amount of friction experienced by door 12 and/or lock device 22(b) in opening and/or closing, as applied by the intelligent door lock system 10(a) and the positioning sensing device 16(c) to the drive shaft 14(b). The circuit 18 and engine/processor 36 can provide for an adjustment of current. The engine/processor 36 can provide information regarding the door and friction to the user of the door 12.

In one embodiment of the present invention, the intelligent door lock system 10(a) provides an ability to sense friction on the lock device 22(b) and/or door 12 by measuring the torque required to move the bolt/lock 24. The intelligent door lock system 10(a) increases the applied torque gradually until the bolt/lock 24 moves into its desired position, and the applied torque is the minimum amount of torque required to move the bolt/lock 24, which is directly related to how deformed the door is.

In one embodiment, when a bad door is detected, a customer can be notified that their door may require some servicing. In one embodiment, door deformation can be detected with a torque device is used to determine if the torque applied when the door is rotated is too high. As a non-limiting example, this can be 2-15 in lbs of torque. The intelligent door lock system back end 68 can then perform a comparison between the measured torque with a standard, or a norm that is included in the one or more databases 88.

In one embodiment of the present invention, before the door is serviced, the intelligent door lock system 10(a) allows operation by offering a high-friction mode. As a non-limiting example, the high friction mode is when, as non-limiting examples, 2 inch lbs, 3 inch lbs., 3.5 inch pounds, and the like are required to open the door. In the high friction mode, the bolt/lock 24 is driven while the user is pushing, lifting, torqueing the door, pulling, performing visual inspections of rust, blockage, other conditions that can compromise a door and the like, that is applied to the doorknob. The position sensing device 16(c) is used to determine if the bolt/lock 24 was moved to a final position. In the high friction mode, motion of the door closing is confirmed. Upon detecting the closing of the door, the bolt/lock 24 is then driven. When the

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user receives an auditory, visual, or any other type of perceptible confirmation, the user then knows that the door has been locked. In one embodiment, the firmware elements, of the intelligent door lock system 10(a), as well as other door lock device 22(b) elements, can also attempt to drive the bolt/lock 24 for a second time when the first time fails. However, this can result in more power consumption, reducing lifetime of the power source, particularly when it is battery 50 based.

In one embodiment of the present invention, the intelligent door lock system 10(a) seeks to have the motor 38 operate with reduced energy consumption for energy source lifetime purposes, as well as eliminate or reduce undesirable noises, operations, and user experiences that occur when this is a failure in door locking and unlocking, particularly due to door deformation, door non-alignment, as well as other problems with the door that can be irritating to the person locking or unlocking the door.

In one embodiment of the present invention, the intelligent door lock system back-end 68 can track performance of doors and friction levels across time and build a service to encourage users to better maintain their doors. Such service can be a comparison of a door's friction level to other users that are similar geographic locations, at similar weather pattern, such that the user is encouraged to maintain their doors at a competent level. There can be a comparison to standards that at a certain level the door becomes unsafe. Guidelines are provided as to how to maintain their doors. This can be achieved by asking a door user what improves their door, including but not limited to, pushing, lifting, torqueing the door, pulling, visual inspections of rust, blockage, other conditions that can compromise a door, and the like. The analysis and comparison can be conducted at the back-end 68 and the results computed to door lock operator as well as others.

In one embodiment of the present invention, the intelligent door lock system 10(a) has a deformed operation mode that can be activated after a selected amount of time. As a non-limiting example, this can immediately after the user has been notified, more than 1 pica second, 1 second, 5 seconds, and greater periods of time. The deformed operation mode can be activated by the intelligent door lock system 10(a) itself, or by the intelligent door lock system back-end 68. It can be activated on the door operator's request. In one embodiment, the back-end 68 can anticipate these problems. As non-limiting examples, these can include but are not limited to, due to analysis of doors 12 in similar geographic areas, doors under similar conditions, doors with similar histories, similar environmental conditions, as well as the history of a particular door, and the like.

The deformed mode provides cooperation with the door user to more readily open the door. In one embodiment, this is a mechanism for the door to communicate back to the door lock operator. As a non-limiting example, feedback can be provided to the door operator. Such feedback can include, but is not limited to, communication via, tactile, audio, visual, temperature, electronic, wirelessly, through a computer, mobile device and the like. In another embodiment, the operator can signify to the door the operator's desire to leave by unlocking and opening the door 12. This is a door operator and lock communication. The door operator can close the door, which is sensed by the intelligent door lock system 10(a), a timer can then be initiated to provide with door operator with a selected time period in which the door operator can manually alleviate the friction problem. When the time has expired, the intelligent door system 10(a) can then lock the door 12. Upon detecting a successful door locking event, the intelligent door lock system 10(a) can advise the door operator that there is a successful door locking. If the

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door locking is not successful, the intelligent door lock system **10(a)** can provide a message to the door operator via a variety of means, including but not limited to a message or alert to the door lock operator's mobile device. Such a mobile device message provides the door operator with notification that door locking was not successful or achieved, and the door lock operator can then take action to lock the door **12** either in person, wirelessly, and the like.

For entry, communication with the lock device **22(b)** may be different. In one embodiment, it can be locking coupled with close proximity to a mobile device that is exterior to the door.

In another embodiment of the present invention, the intelligent door lock system back-end **68** can track performance of doors and friction levels across time and build a simple service to encourage users to maintain their doors better, as discussed above.

This information can be stored in the one or more databases **64**.

In one embodiment of the present invention, the intelligent door lock system **10(a)** unlocks when a selected temperature is reached, when smoke is detected, when a fire is detected by processor **38** and the like. As non-limiting examples, the intelligent door lock system **10(a)** unlocks the bolt/lock **24** when a temperature is sensed by the temperature sensor that, as non-limiting examples, is greater than 40 degrees C., any temperature over 45 degrees C. and the like. The temperature sensor **46 212** sends a signal to the processor **36** which communicates with the motor **38** that will then cause the drive shaft **14(b)** to rotate sufficiently and unlock the bolt/lock **24**. An arm can also be activated. It will be appreciated that the processor **36** can be anywhere as long as it is in communication with the temperature sensor **46**, and the motor **38**, which can be at the intelligent door lock system **10(a)**, at the back-end **68**, anywhere in the building, and at any remote location. The processor **36** determines if there is an unsafe condition, e.g., based on a rise in temperature and this then results in an unlocking of the bolt/lock **24**.

In one embodiment, the intelligent door lock system back-end **68** can track performance of doors and friction levels across time and build a service to encourage users to better maintain their doors, as discussed above.

FIG. **17** is a diagram illustrating an implementation of an intelligent door lock system **100** that allows an intelligent lock on one or more buildings to be controlled, as described above, and also controlled remotely by a mobile device or computer, as well as remotely by an intelligent lock system back-end component **114**, a mobile device or a computing device **210** of a user who is a member of the intelligent door lock system **100**, as disclosed above. The intelligent door lock system back-end component **114** may be any of those listed above included in the intelligent lock system back-end **68**, one or more computing resources, such as cloud computing resources or server computers with the typical components, that execute a plurality of lines of computer code to implement the intelligent door lock system **100** functions described above and below. Each computing device **210** of a user may be a processing unit based device with sufficient processing power, memory and connectivity to interact with the intelligent door lock system back-end component **114**. As a non-limiting example, the mobile device or computing device **210** may be as defined above, and include those disclosed below, that is capable of interacting with the intelligent door lock back-end component **114**. In one implementation, the mobile device or computing device **210** may execute an application stored in the memory of the mobile device computing device **210** using a processor from the mobile device or computing

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device **210** to interact with the intelligent door lock back-end component **114**. Examples of a user interface for that application is shown in FIGS. **21(a)-22(e)** discussed below in more detail.

In another embodiment, the mobile device or computing device **210** may execute a browser stored in the memory of the mobile or computing device **210** using a processor from the mobile device or computing device **210** to interact with the intelligent door lock system back-end component **114**. Each of the elements shown in FIG. **17** may be linked by System Networks, including but not limited to a cellular network, a Bluetooth system, the Internet (HTTPS), a WiFi network and the like.

As shown in FIG. **17**, each user's mobile device or computer **210** may interact with the intelligent door lock system back-end **68** over System Networks, including but not limited to a wired or wireless network, such as a cellular network, digital data network, computer network and may also interact with the intelligent door lock system **10(a)** using System Networks. Each mobile device or computing device **210** may also communicate with a WiFi network **115** or Network Systems over, as a non-limiting example, a network and the WiFi network **115** may then communicate with the intelligent door lock system **10(a)**.

FIGS. **1B(a)** and **(b)** illustrate a front view and a back view, respectively, of a door **120** with intelligent door lock system **10(a)**. The front portion of the door **120** (that is outside relative to a building or dwelling) shown in FIG. **17** looks like a typical door **120** with a bolt assembly **122** and a doorknob and lock assembly **124**. The back portion of the door **120**, that is inside of the dwelling when the door **120** is closed, illustrated in FIG. **1(b)** has the same doorknob and lock assembly **124**, but then has an intelligent door lock system **100** that is retrofitted onto the bolt assembly **124** as described below in more detail.

The intelligent door lock assembly **100** may have an extension gear which extends through the baseplate of the smart door lock. The baseplate may have one or more oval mounting holes to accommodate various rose screw distances from 18 mm to 32 mm to accommodate various different doors. In one implementation, the intelligent door lock system **100** may have a circular shape and also a rotating bezel. The rotating bezel allows a user to rotate the smart door lock and thus manually lock or unlock the bolt as before. The extension gear extends through the baseplate and then interacts with the existing bolt elements and allows the smart door lock to lock/unlocks the bolt. The extension gear may have a modular adapter slot at its end which interfaces with an extension rod of the bolt assembly **124**. These modular adapters, as shown in FIG. **23(b)**, may be used to match the existing extension rod of the bolt assembly **124**. The smart door lock housing may further include an energy source, such as a battery, a motor assembly, such as a compact, high-torque, high-accuracy stepper motor, and a circuit board that has at least a processor, a first wireless connectivity circuit and a second wireless connectivity circuit, as described above. In one embodiment, the first wireless connectivity circuit may be a Bluetooth chip that allows the smart door lock to communicate using a Bluetooth protocol with a computing device of a user, such as a smartphone, tablet computer and the like. The second wireless connectivity circuit may be a WiFi chip that allows the smart door lock to communicate using a WiFi protocol with a back-end server system. The circuit board components may be intercoupled to each other and also coupled to the energy source and the motor for power and to control the motor,

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respectively. Each of the components described here may be coupled to the energy source and powered by the energy source.

FIG. 19 illustrates the smart door lock system 100 being retrofitted onto a bolt in a door 12. As shown in FIG. 19, when the intelligent door lock system 100 is installed on the door 120, the thumb turn 124 is removed (replaced by the bezel that allows the user to manually unlock or lock the bolt.) In addition, the extension gear 126 of the intelligent door lock system 100, and more specifically the slotted portion 126(a) at the end of the extension gear, is mechanically coupled to the extension rod 128 of the bolt assembly as shown in FIG. 19. When the intelligent door lock system 100 is installed, as shown in FIG. 19, the user can rotate the bezel 132 to manually lock or unlock the bolt assembly. In addition, when commanded to do so, the motor assembly in the intelligent door lock system 100 can also turn the extension gear 126 that in turn turns the extension rod and lock or unlock the bolt assembly. Thus, the extension gear 126 allows the smart door lock to act as a manual thumb turn (using the bezel) and rotate either clockwise or counterclockwise to engage or disengage the bolt of a door. The extension gear 126 is designed in a manner to control the physical rotation of extension rods/axial actuators/tail pieces/tongues 128 which are traditionally rotated by means of a thumb turn. This is achieved by designing the extension gear 126 with modular gear adapters as shown in FIG. 23(b) to fit over the extension rod as shown. This allows the extension gear 126 to fit with a variety of existing extension rods.

FIG. 20 illustrates a set of interactions between the intelligent door lock system 100, mobile or computing device 210 and intelligent door lock system back-end 68 that may include a pairing process 138 and a lock operation process 140. During the pairing process 138, the intelligent door lock system 100 and mobile or computing device 210 can be paired to each other and also authenticated by the intelligent door lock system back-end 68. Thus, as shown in FIG. 20, during the pairing process, the intelligent door lock system 100 is powered on and becomes discoverable, while the mobile or computing device 210 communicates with the intelligent door lock system back-end 68, and has its credentials validated and authenticated. Once the mobile or computing device 210, and the app on the mobile or computing device 210, is authenticated, the mobile or computing device 210 discovers the lock, such as through a Bluetooth discovery process, since the intelligent door lock system 100 and the mobile or computing device 210 are within a predetermined proximity to each other. The mobile or computing device 210 may then send a pairing code to the intelligent door lock system 100, and in turn receive a pairing confirmation from the intelligent door lock system 100. The pairing process is then completed with the processes illustrated in FIG. 20. The lock operation may include the steps listed in FIG. 20 to operate the intelligent door lock system 100 wirelessly using the mobile or computing device 210.

The intelligent door lock system 100 may be used for various functions. As a non-limiting example, the intelligent door lock system 100 may enable a method to exchange a security token between mobile or computing device 210 and the intelligent door lock system 100. All or all of the intelligent door lock systems 100 may be registered with the intelligent door lock back-end 68 with a unique registration ID. The unique ID of the intelligent door lock system 100 may be associated with a unique security token that can only be used to command a specific intelligent door lock system 100 to lock or unlock. Through a virtual key provisioning interface of the intelligent door lock system back-end 68, a master

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user, who may be an administrator, can issue a new security token to a particular mobile or computing device 210. The intelligent door lock system 100 can periodically broadcast an advertisement of its available services over System Networks. When the mobile or computing device 210 is within a predetermined proximity of the intelligent door lock system 100, which varies depending on the protocol being used, the mobile or computing device 210 can detect the advertisement from the intelligent door lock assembly 100.

The application on the mobile or computing device 210 detects the intelligent door lock system 100 and a communications session can be initiated. The token, illustrated as a key 118 in FIG. 20, is exchanged and the lock is triggered to unlock automatically. Alternatively, if the intelligent door lock system 100 is equipped with a second wireless communications circuit, then the intelligent door lock system 100 can periodically query the intelligent door lock system back-end 68 for commands. A user can issue commands via a web interface to the intelligent door lock system back-end 68, and the intelligent door lock system 100 can lock or unlock the door 120. The intelligent door lock system 100 may also allow the user to disable auto-unlock, at which time the application on the user's mobile or computing device 210 can provide a notification which then allows the user to press a button on the mobile or computing device 210 to lock or unlock the lock.

The intelligent door lock system 100 may also allow for the triggering of multiple events upon connection to an intelligent door lock system 100 by a mobile or computing device 210. As a non-limiting example, the intelligent door lock system 100 can detect and authenticate the mobile or computing device 210, as described herein, and initiate a series of actions, including but not limiting to, unlocking doors 100, turning on lights, adjusting temperature, turning on stereo etc. The commands for these actions may be carried out by the mobile or computing device 210 or the intelligent door lock system back-end 68. In addition, through a web interface of the intelligent door lock system back-end 68, the user may define one or more events to be triggered upon proximity detection and authentication of the user's mobile or computing device 210 to the intelligent door lock system 100.

The intelligent door lock system 100 may also allow for the intelligent triggering of events associated with an individual. In particular, environmental settings may be defined per individual in the intelligent door lock system back-end 68 and then applied intelligently by successive ingress by that person into a building that has an intelligent door lock system 100. For example: person A arrives home and its mobile or computing device 210 is authenticated by the intelligent door lock system 100. His identity is shared with the intelligent door lock system back-end 68. The intelligent door lock system back-end 68 may send environmental changes to other home controllers, such as "adjust heat to 68 degrees". Person B arrives at the same building an hour later and her mobile or computing device 210 is also authenticated and shared with the intelligent door lock system back-end 68. The intelligent door lock system back-end 68 accesses her preferred environmental variables such as "adjust heat to 71 degrees". The intelligent door lock system back-end understands that person B has asked for a temperature increase and issues the respective command to the dwelling thermostat. In one example, the intelligent door lock back-end system 68 has logic that defers to the higher temperature request or can deny it. Therefore if person A entered the home after person B, the temperature would not be decreased.

FIGS. 21(a)-(g) are examples of a user interface for an owner of a building that has an intelligent door lock system

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100. These user interfaces may be seen by a user who is the owner of a building that has an intelligent door lock system 100 with the unique ID. FIG. 21(a) is a basic home screen while FIG. 22(b) shows the smart door locks (in a keychain) which the user of the mobile or computing device 210 has access rights to in intelligent door lock system 100. FIG. 21(c) illustrates an example of a user interface when a particular intelligent door lock system 100 is locked. FIG. 22(d) illustrates an example of a user interface when a particular intelligent door lock system 100 is unlocked. FIGS. 21(e) and (f) are user interface examples that allow the owner to add other users/people to be able to control the intelligent door lock system 100 of the building. FIG. 21(g) is an example of a configuration interface that allows the owner of the building to customize a set of permissions assigned for each intelligent door lock system 100.

FIGS. 22(a)-(e) are examples of a user interface for a guest of an owner of a building that has an intelligent door lock system 100.

FIGS. 23(a) and (b) illustrate an intelligent door lock system 100 and extension gear adapters 142. In particular, FIG. 23(a) shows the bolt of a lock device with an empty extension gear receptacle that allows different extension gear adapters 150 (shown in FIG. 23(a)) to be inserted into the receptacle so that the an intelligent door lock system 100 may be used with a number of different bolts of lock devices that each have a different shaped extension rod and/or extension rods that have different cross-sections.

Referring now to FIG. 24, 1212 is a block diagram illustrating embodiments of a mobile or computing device 210 that can be used with intelligent door lock system 100(a).

The mobile or computing device 210 can include a display 1214 that can be a touch sensitive display. The touch-sensitive display 1214 is sometimes called a "touch screen" for convenience, and may also be known as or called a touch-sensitive display system. The mobile or computing device 210 may include a memory 1216 (which may include one or more computer readable storage mediums), a memory controller 1218, one or more processing units (CPU's) 1220, a peripherals interface 1222, Network Systems circuitry 1244, including but not limited to RF circuitry, audio circuitry 1226, a speaker 1228, a microphone 1230, an input/output (I/O) subsystem 1232, other input or control devices 1234, and an external port 1236. The mobile or computing device 210 may include one or more optical sensors 1238. These components may communicate over one or more communication buses or signal lines 1240.

It should be appreciated that the mobile or computing device 210 is only one example of a portable multifunction mobile or computing device 210, and that the mobile or computing device 210 may have more or fewer components than shown, may combine two or more components, or may have a different configuration or arrangement of the components. The various components shown in FIG. 24 may be implemented in hardware, software or a combination of hardware and software, including one or more signal processing and/or application specific integrated circuits.

Memory 1216 may include high-speed random access memory and may also include non-volatile memory, such as one or more magnetic disk storage devices, flash memory devices, or other non-volatile solid-state memory devices. Access to memory 1216 by other components of the mobile or computing device 210, such as the CPU 1220 and the peripherals interface 1222, may be controlled by the memory controller 1218.

The peripherals interface 1222 couples the input and output peripherals of the device to the CPU 1220 and memory

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1216. The one or more processors 1220 run or execute various software programs and/or sets of instructions stored in memory 1216 to perform various functions for the mobile or computing device 210 and to process data.

In some embodiments, the peripherals interface 1222, the CPU 1220, and the memory controller 1218 may be implemented on a single chip, such as a chip 1242. In some other embodiments, they may be implemented on separate chips.

The Network System circuitry 1244 receives and sends signals, including but not limited to RF, also called electromagnetic signals. The Network System circuitry 1244 converts electrical signals to/from electromagnetic signals and communicates with communications networks and other communications devices via the electromagnetic signals. The Network Systems circuitry 1244 may include well-known circuitry for performing these functions, including but not limited to an antenna system, an RF transceiver, one or more amplifiers, a tuner, one or more oscillators, a digital signal processor, a CODEC chipset, a subscriber identity module (SIM) card, memory, and so forth. The Network Systems circuitry 1244 may communicate with networks, such as the Internet, also referred to as the World Wide Web (WWW), an intranet and/or a wireless network, such as a cellular telephone network, a wireless local area network (LAN) and/or a metropolitan area network (MAN), and other devices by wireless communication.

The wireless communication may use any of a plurality of communications standards, protocols and technologies, including but not limited to Global System for Mobile Communications (GSM), Enhanced Data GSM Environment (EDGE), high-speed downlink packet access (HSDPA), wideband code division multiple access (W-CDMA), code division multiple access (CDMA), time division multiple access (TDMA), BLUETOOTH®, Wireless Fidelity (Wi-Fi) {e.g., IEEE 802.11a, IEEE 802.11b, IEEE 802.11g and/or IEEE 802.11n}, voice over Internet Protocol (VoIP), Wi-MAX, a protocol for email (e.g., Internet message access protocol {IMAP} and/or post office protocol (POP)), instant messaging (e.g., extensible messaging and presence protocol (XMPP), Session Initiation Protocol for Instant Messaging and Presence Leveraging Extensions (SIMPLE), and/or Instant Messaging and Presence Service (IMPS)), and/or Short Message Service (SMS)), or any other suitable communication protocol, including communication protocols not yet developed as of the filing date of this document.

The audio circuitry 1226, the speaker 1228, and the microphone 1230 provide an audio interface between a user and the mobile or computing device 210. The audio circuitry 1226 receives audio data from the peripherals interface 1222, converts the audio data to an electrical signal, and transmits the electrical signal to the speaker 1228. The speaker 1228 converts the electrical signal to human-audible sound waves. The audio circuitry 1226 also receives electrical signals converted by the microphone 1230 from sound waves. The audio circuitry 1226 converts the electrical signal to audio data and transmits the audio data to the peripherals interface 1222 for processing. Audio data may be retrieved from and/or transmitted to memory 1216 and/or the Network Systems circuitry 1244 by the peripherals interface 1222. In some embodiments, the audio circuitry 1226 also includes a headset jack. The headset jack provides an interface between the audio circuitry 1226 and removable audio input/output peripherals, such as output-only headphones or a headset with both output (e.g., a headphone for one or both ears) and input (e.g., a microphone).

The I/O subsystem 1232 couples input/output peripherals on the mobile or computing device 210, such as the touch

screen **1214** and other input/control devices **1234**, to the peripherals interface **1222**. The I/O subsystem **1232** may include a display controller **1246** and one or more input controllers **210** for other input or control devices. The one or more input controllers **1** receive/send electrical signals from/to other input or control devices **1234**. The other input/control devices **1234** may include physical buttons (e.g., push buttons, rocker buttons, etc.), dials, slider switches, and joysticks, click wheels, and so forth. In some alternate embodiments, input controller(s) **1252** may be coupled to any (or none) of the following: a keyboard, infrared port, USB port, and a pointer device such as a mouse. The one or more buttons may include an up/down button for volume control of the speaker **1228** and/or the microphone **1230**. The one or more buttons may include a push button. A quick press of the push button may disengage a lock of the touch screen **1214** or begin a process that uses gestures on the touch screen to unlock the device, as described in U.S. patent application Ser. No. 11/322,549, "Unlocking a Device by Performing Gestures on an Unlock Image," filed Dec. 23, 2005, which is hereby incorporated by reference in its entirety. A longer press of the push button may turn power to the mobile or computing device **210** on or off. The user may be able to customize a functionality of one or more of the buttons. The touch screen **1214** is used to implement virtual or soft buttons and one or more soft keyboards.

The touch-sensitive touch screen **1214** provides an input interface and an output interface between the device and a user. The display controller **1246** receives and/or sends electrical signals from/to the touch screen **1214**. The touch screen **1214** displays visual output to the user. The visual output may include graphics, text, icons, video, and any combination thereof (collectively termed "graphics"). In some embodiments, some or all of the visual output may correspond to user-interface objects, further details of which are described below.

A touch screen **1214** has a touch-sensitive surface, sensor or set of sensors that accepts input from the user based on haptic and/or tactile contact. The touch screen **1214** and the display controller **1246** (along with any associated modules and/or sets of instructions in memory **1216**) detect contact (and any movement or breaking of the contact) on the touch screen **1214** and converts the detected contact into interaction with user-interface objects (e.g., one or more soft keys, icons, web pages or images) that are displayed on the touch screen. In an exemplary embodiment, a point of contact between a touch screen **1214** and the user corresponds to a finger of the user.

The touch screen **1214** may use LCD (liquid crystal display) technology, or LPD (light emitting polymer display) technology, although other display technologies may be used in other embodiments. The touch screen **1214** and the display controller **1246** may detect contact and any movement or breaking thereof using any of a plurality of touch sensing technologies now known or later developed, including but not limited to capacitive, resistive, infrared, and surface acoustic wave technologies, as well as other proximity sensor arrays or other elements for determining one or more points of contact with a touch screen **1214**.

A touch-sensitive display in some embodiments of the touch screen **1214** may be analogous to the multi-touch sensitive tablets described in the following U.S. Pat. No. 6,323,846 (Westerman et al.), U.S. Pat. No. 6,570,557 (Westerman et al.), and/or U.S. Pat. No. 6,677,932 (Westerman), and/or U.S. Patent Publication 2002/0015024A1, each of which is hereby incorporated by reference in their entirety. However, a touch screen **1214** displays visual output from the portable

mobile or computing device **210**, whereas touch sensitive tablets do not provide visual output.

A touch-sensitive display in some embodiments of the touch screen **1214** may be as described in the following applications: (1) U.S. patent application Ser. No. 11/381,313, "Multipoint Touch Surface Controller," filed May 12, 2006; (2) U.S. patent application Ser. No. 10/840,862, "Multipoint Touchscreen," filed May 6, 2004; (3) U.S. patent application Ser. No. 10/903,964, "Gestures For Touch Sensitive Input Devices," filed Jul. 30, 2004; (4) U.S. patent application Ser. No. 11/048,264, "Gestures For Touch Sensitive Input Devices," filed Jan. 31, 2005; (5) U.S. patent application Ser. No. 11/038,590, "Mode-Based Graphical User Interfaces For Touch Sensitive Input Devices," filed Jan. 18, 2005; (6) U.S. patent application Ser. No. 11/228,758, "Virtual Input Device Placement On A Touch Screen User Interface," filed Sep. 16, 2005; (7) U.S. patent application Ser. No. 11/228,700, "Operation Of A Computer With A Touch Screen Interface," filed Sep. 16, 2005; (8) U.S. patent application Ser. No. 11/228,737, "Activating Virtual Keys Of A Touch-Screen Virtual Keyboard," filed Sep. 16, 2005; and (9) U.S. patent application Ser. No. 11/367,749, "Multi-Functional Hand-Held Device," filed Mar. 3, 2006. All of these applications are incorporated by reference herein in their entirety.

The touch screen **1214** may have a resolution in excess of 1000 dpi. In an exemplary embodiment, the touch screen has a resolution of approximately 1060 dpi. The user may make contact with the touch screen **1214** using any suitable object or appendage, such as a stylus, a finger, and so forth. In some embodiments, the user interface is designed to work primarily with finger-based contacts and gestures, which are much less precise than stylus-based input due to the larger area of contact of a finger on the touch screen. In some embodiments, the device translates the rough finger-based input into a precise pointer/cursor position or command for performing the actions desired by the user.

In some embodiments, in addition to the touch screen, the mobile or computing device **210** may include a touchpad (not shown) for activating or deactivating particular functions. In some embodiments, the touchpad is a touch-sensitive area of the device that, unlike the touch screen, does not display visual output. The touchpad may be a touch-sensitive surface that is separate from the touch screen **1214** or an extension of the touch-sensitive surface formed by the touch screen.

In some embodiments, the mobile or computing device **210** may include a physical or virtual click wheel as an input control device **1234**. A user may navigate among and interact with one or more graphical objects (henceforth referred to as icons) displayed in the touch screen **1214** by rotating the click wheel or by moving a point of contact with the click wheel (e.g., where the amount of movement of the point of contact is measured by its angular displacement with respect to a center point of the click wheel). The click wheel may also be used to select one or more of the displayed icons. For example, the user may press down on at least a portion of the click wheel or an associated button. User commands and navigation commands provided by the user via the click wheel may be processed by an input controller **1252** as well as one or more of the modules and/or sets of instructions in memory **1216**. For a virtual click wheel, the click wheel and click wheel controller may be part of the touch screen **1214** and the display controller **1246**, respectively. For a virtual click wheel, the click wheel may be either an opaque or semitransparent object that appears and disappears on the touch screen display in response to user interaction with the device. In some embodiments, a virtual click wheel is dis-

played on the touch screen of a portable multifunction device and operated by user contact with the touch screen.

The mobile or computing device **210** also includes a power system **1214** for powering the various components. The power system **1214** may include a power management system, one or more power sources (e.g., battery **1254**, alternating current (AC)), a recharging system, a power failure detection circuit, a power converter or inverter, a power status indicator (e.g., a light-emitting diode (LED)) and any other components associated with the generation, management and distribution of power in portable devices.

The mobile or computing device **210** may also include one or more sensors **1238**, including not limited to optical sensors **1238**. An optical sensor can be coupled to an optical sensor controller **1248** in I/O subsystem **1232**. The optical sensor **1238** may include charge-coupled device (CCD) or complementary metal-oxide semiconductor (CMOS) phototransistors. The optical sensor **1238** receives light from the environment, projected through one or more lens, and converts the light to data representing an image. In conjunction with an imaging module **1258** (also called a camera module); the optical sensor **1238** may capture still images or video. In some embodiments, an optical sensor is located on the back of the mobile or computing device **210**, opposite the touch screen display **1214** on the front of the device, so that the touch screen display may be used as a viewfinder for either still and/or video image acquisition. In some embodiments, an optical sensor is located on the front of the device so that the user's image may be obtained for videoconferencing while the user views the other video conference participants on the touch screen display. In some embodiments, the position of the optical sensor **1238** can be changed by the user (e.g., by rotating the lens and the sensor in the device housing) so that a single optical sensor **1238** may be used along with the touch screen display for both video conferencing and still and/or video image acquisition.

The mobile or computing device **210** may also include one or more proximity sensors **1250**. In one embodiment, the proximity sensor **1250** is coupled to the peripherals interface **1222**. Alternately, the proximity sensor **1250** may be coupled to an input controller in the I/O subsystem **1232**. The proximity sensor **1250** may perform as described in U.S. patent application Ser. No. 11/241,839, "Proximity Detector In Handheld Device," filed Sep. 30, 2005; Ser. No. 11/240,788, "Proximity Detector In Handheld Device," filed Sep. 30, 2005; Ser. No. 13/096,386, "Using Ambient Light Sensor To Augment Proximity Sensor Output"; Ser. No. 11/586,862, "Automated Response To And Sensing Of User Activity In Portable Devices," filed Oct. 24, 2006; and Ser. No. 11/638,251, "Methods And Systems For Automatic Configuration Of Peripherals," which are hereby incorporated by reference in their entirety. In some embodiments, the proximity sensor turns off and disables the touch screen **1214** when the multifunction device is placed near the user's ear (e.g., when the user is making a phone call). In some embodiments, the proximity sensor keeps the screen off when the device is in the user's pocket, purse, or other dark area to prevent unnecessary battery drainage when the device is a locked state.

In some embodiments, the software components stored in memory **1216** may include an operating system **1260**, a communication module (or set of instructions) **1262**, a contact/motion module (or set of instructions) **1264**, a graphics module (or set of instructions) **1268**, a text input module (or set of instructions) **1270**, a Global Positioning System (GPS) module (or set of instructions) **1272**, and applications (or set of instructions) **1272**.

The operating system **1260** (e.g., Darwin, RTXC, LINUX, UNIX, OS X, WINDOWS, or an embedded operating system such as VxWorks) includes various software components and/or drivers for controlling and managing general system tasks (e.g., memory management, storage device control, power management, etc.) and facilitates communication between various hardware and software components.

The communication module **1262** facilitates communication with other devices over one or more external ports **1274** and also includes various software components for handling data received by the Network Systems circuitry **1244** and/or the external port **1274**. The external port **1274** (e.g., Universal Serial Bus (USB), FIREWIRE, etc.) is adapted for coupling directly to other devices or indirectly over a network (e.g., the Internet, wireless LAN, etc.). In some embodiments, the external port is a multi-pin (e.g., 30-pin) connector that is the same as, or similar to and/or compatible with the 30-pin connector used on iPod (trademark of Apple Computer, Inc.) devices.

The contact/motion module **106** may detect contact with the touch screen **1214** (in conjunction with the display controller **1246**) and other touch sensitive devices (e.g., a touchpad or physical click wheel). The contact/motion module **106** includes various software components for performing various operations related to detection of contact, such as determining if contact has occurred, determining if there is movement of the contact and tracking the movement across the touch screen **1214**, and determining if the contact has been broken (i.e., if the contact has ceased). Determining movement of the point of contact may include determining speed (magnitude), velocity (magnitude and direction), and/or an acceleration (a change in magnitude and/or direction) of the point of contact. These operations may be applied to single contacts (e.g., one finger contacts) or to multiple simultaneous contacts (e.g., "multitouch"/multiple finger contacts). In some embodiments, the contact/motion module **106** and the display controller **1246** also detects contact on a touchpad. In some embodiments, the contact/motion module **1284** and the controller **1286** detects contact on a click wheel.

Examples of other applications that may be stored in memory **1216** include other word processing applications, JAVA-enabled applications, encryption, digital rights management, voice recognition, and voice replication.

In conjunction with touch screen **1214**, display controller **1246**, contact module **1276**, graphics module **1278**, and text input module **1280**, a contacts module **1282** may be used to manage an address book or contact list, including: adding name(s) to the address book; deleting name(s) from the address book; associating telephone number(s), e-mail address(es), physical address(es) or other information with a name; associating an image with a name; categorizing and sorting names; providing telephone numbers or e-mail addresses to initiate and/or facilitate communications by telephone, video conference, e-mail, or IM; and so forth.

Algorithm for Sound Analysis

The data center **28** includes a system for sound analysis for sounds received from the bridge. In one embodiment the system includes an audio processing engine, a conditioning module, and an audio sink. Further components not related to reconstruction of the audio signal may be provided in the system. Additionally, while the system describes a logical progression of data from each component of FIG. 1 to the next, alternative embodiments may comprise the various components of the system coupled via one or more buses or other elements.

The exemplary audio processing engine processes the input (audio) signals inputted via the audio source. In one

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embodiment, the audio processing engine comprises software stored on a device which is operated upon by a general processor. The audio processing engine, in various embodiments, comprises an analysis filter bank module, a modification module, and a reconstruction module. It should be noted that more, less, or functionally equivalent modules may be provided in the audio processing engine. For example, one or more the modules may be combined into few modules and still provide the same functionality.

The conditioning module pre-processes the input signal (i.e., any processing that does not require decomposition of the input signal). In one embodiment, the conditioning module comprises an auto-gain control. The conditioning module may also perform error correction and noise filtering. The conditioning module may comprise other components and functions for pre-processing the audio signal.

The analysis filter bank module decomposes the received input signal into a plurality of sub-band signals. In some embodiments, the outputs from the analysis filter bank module can be used directly (e.g., for a visual display.) The analysis filter bank module will be discussed in more detail in connection with FIG. 26. In exemplary embodiments, each sub-band signal represents a frequency component.

The exemplary modification module receives each of the sub-band signals over respective analysis paths from the analysis filter bank module. The modification module can modify/adjust the sub-band signals based on the respective analysis paths. In one example, the modification module filters noise from sub-band signals received over specific analysis paths. In another example, a sub-band signal received from specific analysis paths may be attenuated, suppressed, or passed through a further filter to eliminate objectionable portions of the sub-band signal.

The reconstruction module reconstructs the modified sub-band signals into a reconstructed audio signal for output. In exemplary embodiments, the reconstruction module performs phase alignment on the complex sub-band signals, performs amplitude compensation, cancels the complex portion, and delays remaining real portions of the sub-band signals during reconstruction in order to improve resolution of the reconstructed audio signal. The reconstruction module will be discussed in more details in connection with FIG. 30.

The audio sink comprises any device for outputting the reconstructed audio signal. In some embodiments, the audio sink outputs an analog reconstructed audio signal. For example, the audio sink may comprise a digital-to-analog (D/A) converter and a speaker. In this example, the D/A converter is configured to receive and convert the reconstructed audio signal from the audio processing engine into the analog reconstructed audio signal. The speaker can then receive and output the analog reconstructed audio signal. The audio sink can comprise any analog output device including, but not limited to, headphones, ear buds, or a hearing aid. Alternately, the audio sink comprises the D/A converter and an audio output port configured to be coupled to external audio devices (e.g., speakers, headphones, ear buds, hearing aid.)

In alternative embodiments, the audio sink outputs a digital reconstructed audio signal. In another example, the audio sink is a disk device, wherein the reconstructed audio signal may be stored onto a hard disk or other medium. In alternate embodiments, the audio sink is optional and the audio processing engine produces the reconstructed audio signal for further processing (not depicted in FIG. 25).

Referring now to FIG. 26, the exemplary analysis filter bank module is shown in more detail. In exemplary embodiments, the analysis filter bank module receives an input sig-

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nal, and processes the input signal through a series of filters to produce a plurality of sub-band signals or components (e.g., P1-P6). Any number of filters may comprise the analysis filter bank module. In exemplary embodiments, the filters are complex valued filters. In further embodiments, the filters are first order filters (e.g., single pole, complex valued). The filters are further discussed in FIG. 27.

In exemplary embodiments, the filters are organized into a filter cascade whereby an output of one filter becomes an input in a next filter in the cascade. Thus, the input signal is fed to a first filter a. An output signal P1, of the first filter a is subtracted from the input signal by a first computation node a to produce an output 01. The output 01 represents the difference signal between the signal going into the first filter and the signal after the first filter a.

In alternative embodiments, benefits of the filter cascade may be realized without the use of the computation node to determine sub-band signals. That is, the output of each filter may be used directly to represent energy of the signal at the output or be displayed, for example.

Because of the cascade structure of the analysis filter bank module, the output signal, P1, is now an input signal into a next filter in the cascade. Similar to the process associated with the first filter a, an output of the next filter b (i.e., P2) is subtracted from the input signal P1 by a next computation node b to obtain a next frequency band or channel (i.e., output 02). This next frequency channel emphasizes frequencies between cutoff frequencies of the present filter b and the previous filter a. This process continues through the remainder of the filters of the cascade.

In one embodiment, sets of filters in the cascade are separated into octaves. Filter parameters and coefficients may then be shared among corresponding filters (in a similar position) in different octaves. This process is described in detail in U.S. patent application Ser. No. 09/534,682, incorporated herein by reference.

In some embodiments, the filters are single pole, complex-valued filters. For example, the filters may comprise first order digital or analog filters that operate with complex values. Collectively, the outputs of the filters represent the sub-band components of the audio signal. Because of the computation node, each output represents a sub-band, and a sum of all outputs represents the entire input signal. Since the cascading filters are first order, the computational expense may be much less than if the cascading filters were second order or more. Further, each sub-band extracted from the audio signal can be easily modified by altering the first order filters. In other embodiments, the filters are complex-valued filters and not necessarily single pole.

In further embodiments, the modification module (FIG. 25) can process the outputs of the computation node as necessary. For example, the modification module may half wave rectify the filtered sub-bands. Further, the gain of the outputs can be adjusted to compress or expand a dynamic range. In some embodiments, the output of any filter may be down-sampled before being processed by another chain/cascade of filters.

In exemplary embodiments, the filters are infinite impulse response (IIR) filters with cutoff frequencies designed to produce a desired channel resolution. The filters may perform successive Hilbert transformations with a variety of coefficients upon the complex audio signal in order to suppress or output signals within specific sub-bands.

FIG. 27 is a block diagram illustrating this signal flow in one exemplary embodiment of the present invention. The output of the filter, $\text{real}[n]$ and $\text{imag}[n]$ is passed as an input $\text{xreal}[n+1]$ and $\text{ximag}[n+1]$, respectively, of a next filter in the

cascade. The term “n” identifies the sub-band to be extracted from the audio signal, where “n” is assumed to be an integer. Since the IIR filter is recursive, the output of the filter can change based on previous outputs. The imaginary components of the input signal (e.g., $x_{\text{imag}}[n]$) can be summed after, before, or during the summation of the real components of the signal. In one embodiment, the filter can be described by the complex first order difference equation $y(k)=g*(x(k)+b*x(k-1))+a*y(k-1)$ where $b=r_z*\exp(i*\theta_p)$ and $a=-r_p*\exp(i*\theta_p)$ and “y” is a sample index.

In the present embodiment, “g” is a gain factor. It should be noted that the gain factor can be applied anywhere that does not affect the pole and zero locations. In alternative embodiments, the gain may be applied by the modification module (FIG. 25) after the audio signals have been decomposed into sub-band signals.

Referring now to FIG. 28, an example log display of magnitude and phase for every six (6) sub-bands of an audio signal is shown. The magnitude and phase information is based on outputs from the analysis filter bank module (FIG. 25). That is, the amplitudes shown in FIG. 28 are the outputs (i.e., output D1-D6) from the computation node (FIG. 26). In the present example, the analysis filter bank module is operating at a 16 kHz sampling rate with sub-bands for a frequency range from 80 Hz to 8 kHz. End-to-end latency of this analysis filter bank module is 17.3 ms.

In some embodiments, it is desirable to have a wide frequency response at high frequencies and a narrow frequency response at low frequencies. Because embodiments of the present invention are adaptable to many audio sources (FIG. 25), different bandwidths at different frequencies may be used. Thus, fast responses with wide bandwidths at high frequencies and slow response with a narrow, short bandwidth at low frequencies may be obtained. This results in responses that are much more adapted to the human ear with relatively low latency (e.g., 12 ms).

Referring now to FIG. 29, an example of magnitude and phase per stage of an analytic cochlea design is shown. The amplitude shown in FIG. 29 is the outputs of filters of FIG. 26 (e.g., P1-P6).

FIG. 30 illustrates operation of the reconstruction module according to one embodiment of the present invention. In exemplary embodiments, the phase of each sub-band signal is aligned, amplitude compensation is performed, the complex portion of each sub-band signal is removed, and then time is aligned by delaying each sub-band signal as necessary to achieve a flat reconstruction spectrum and reduce impulse response dispersion.

Because the filters use complex signals (e.g., real and imaginary parts), phase may be derived for any sample. Additionally, amplitude may also be calculated by $A=\sqrt{\text{square root over } ((y_{\text{real}}[n])^2+(y_{\text{imag}}[n])^2))}$. Thus, the reconstruction of the audio signal is mathematically made easier. As a result of this approach, the amplitude and phase for any sample is readily available for further processing (i.e., to the modification module (FIG. 25)).

Since the impulse responses of the sub-band signals may have varying group delays, merely summing up the outputs of the analysis filter bank module (FIG. 25) may not provide an accurate reconstruction of the audio signal. Consequently, the output of a sub-band can be delayed by the sub-band’s impulse response peak time so that all sub-band filters have their impulse response envelope maximum at a same instance in time.

In an embodiment where the impulse response waveform maximum is later in time than the desired group delay, the

filter output is multiplied with a complex constant such that the real part of the impulse response has a local maximum at the desired group delay.

As shown, sub-band signals (e.g., S_0 , S_n , and S_m) are received by the reconstruction module from the modification module (FIG. 25). Coefficients (e.g., a_0 , a_n , and a_m) are then applied to the sub-band signal. The coefficient comprises a fixed, complex factor (i.e., comprising a real and imaginary portion). Alternately, the coefficients can be applied to the sub-band signal within the analysis filter bank module. The application of the coefficient to each sub-band signal aligns the phases of the sub-band signal and compensates each amplitude. In exemplary embodiments, the coefficients are predetermined. After the application of the coefficient, the imaginary portion is discarded by a real value module (i.e., $\text{Re}\{\}$).

Each real portion of the sub-band signal is then delayed by a delay Z^{-1} . This delay allows for cross sub-band alignment. In one embodiment, the delay Z^{-1} provides a one tap delay. After the delay, the respective sub-band signal is summed in a summation node, resulting in a value. The partially reconstructed signal is then carried into a next summation node and applied to a next delayed sub-band signal. The process continues until all sub-band signals are summed resulting in a reconstructed audio signal. The reconstructed audio signal is then suitable for the audio sink (FIG. 25). Although the delays Z^{-1} are depicted after sub-band signals are summed, the order of operations of the reconstruction module can be interchangeable.

FIG. 31 illustrates a reconstruction graph based on the example of FIG. 28 and FIG. 29. The reconstruction (i.e., reconstructed audio signal) is obtained by combining the outputs of each filter (FIG. 26) after phase alignment, amplitude compensation, and delay for cross sub-band alignment by the reconstruction module (FIG. 25). As a result, the reconstruction graph is relatively flat.

Referring now to FIG. 32, a flowchart of an exemplary method for audio signal processing is provided. An audio signal is decomposed into sub-band signals. In exemplary embodiments, the audio signal is processed by the analysis filter bank module (FIG. 25). The processing comprises filtering the audio signal through a cascade of filters (FIG. 26), the output of each filter resulting in a sub-band signal at the respective outputs. In one embodiment, the filters are complex-valued filters. In a further embodiment, the filters are single pole, complex-valued filters.

After sub-band decomposition, the sub-band signals are processed through the modification module (FIG. 25). In exemplary embodiments, the modification module (FIG. 25) adjusts the gain of the outputs to compress or expand a dynamic range. In some embodiments, the modification module may suppress objectionable sub-band signals.

A reconstruction module (FIG. 25) then performs phase and amplitude compensation on each sub-band signal. In one embodiment, the phase and amplitude compensation occurs by applying a complex coefficient to the sub-band signal. The imaginary portion of the compensated sub-band signal is then discarded. In other embodiments, the imaginary portion of the compensated sub-band signal is retained.

Using the real portion of the compensated sub-band signal, the sub-band signal is delayed for cross-sub-band alignment. In one embodiment, the delay is obtained by utilizing a delay line in the reconstruction module.

The delayed sub-band signals are summed to obtain a reconstructed signal. In exemplary embodiments, each sub-band signal/segment represents a frequency.

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The foregoing description of various embodiments of the claimed subject matter has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the claimed subject matter to the precise forms disclosed. Many modifications and variations will be apparent to the practitioner skilled in the art. Particularly, while the concept "component" is used in the embodiments of the systems and methods described above, it will be evident that such concept can be interchangeably used with equivalent concepts such as, class, method, type, interface, module, object model, and other suitable concepts. Embodiments were chosen and described in order to best describe the principles of the invention and its practical application, thereby enabling others skilled in the relevant art to understand the claimed subject matter, the various embodiments and with various modifications that are suited to the particular use contemplated.

What is claimed is:

1. A Bluetooth/WiFi bridge at a dwelling with a door lock system, comprising:

a computing device in an interior of the dwelling including a first internet-facing radio, and a second radio communicating with one or more non-internet-connected devices, the computing device providing for coordination of information flow between the two radios, the computing device configured to enable the two radios to communicate and take incoming and outgoing information from one radio into a format that the other radio can transmit and receive;

an audio sensor configured to receive a sound from the one or more non-internet connected devices, the audio sensor being coupled to a logic circuit in the computing device, the audio sensor being optionally coupled to the bridge to trigger events or notifications, arm or disarm an alarm, or inform another system at the dwelling; disable an alarm at the dwelling; and

wherein the internet facing radio is configured to communicate through a router to an internet and the non-internet devices connect to the internet via one of the radios through the computing device through the internet facing radio through the router to the internet, with the bridge communicating with a data center, the bridge configured to detect or track movement of a person in an interior of the dwelling, a mobile device at an interior or exterior of the dwelling and configured to provide locking or unlocking of a door of the door lock system, the bridge configured to allow controlled access to the dwelling that includes an occupant of the dwelling as well as a designated third person granted access rights by the occupant.

2. The bridge of claim 1, wherein on a plug side at the dwelling a frequency of sound is determined from the one or more non-internet connected devices.

3. The bridge of claim 1, wherein on a plug side at the dwelling a frequency distribution of sound is determined from the one or more non-internet connected devices.

4. The bridge of claim 1, wherein the bridge determines a frequency of a sound from an alarm.

5. The bridge of claim 4, wherein low power is a power range that uses battery power.

6. The bridge of claim 1, wherein the bridge determines if a sound matches a sound from an alarm.

7. The bridge of claim 6, wherein if the bridge determines that there is a match between a sound and an alarm sound, the sound is communicated to the data center.

8. The bridge of claim 7, wherein the data center includes a plurality of sound signatures.

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9. The bridge of claim 8, wherein the data center matches the sound received from the bridge to the sound signatures.

10. The bridge of claim 9, wherein when the data center finds a match between the sound and a sound signature that represents an alarm sound the data center notifies a user at the dwelling.

11. The bridge of claim 9, wherein when the data center finds a match between the sound and a sound signature that represents an alarm sound the data center notifies an emergency response team.

12. The bridge of claim 9, wherein when the data center finds a match between the sound and a sound signature that represents an alarm sound the data center notifies a human third party to listen to the sound.

13. The bridge of claim 12, wherein at least one of the data center or the human third party is able to distinguish background noises.

14. The bridge of claim 9, wherein the data center sends a signal to unlock a door lock at the dwelling.

15. The bridge of claim 1, wherein the computing device is of a form factor similar to an AC-to-DC power adaptor.

16. The bridge of claim 15, wherein the form factor is configured to provide that it can be grasped by a single hand and plugged into a wall without handling electrical cables and wires.

17. The bridge of claim 16, wherein the electrical cables and wires are configured to be connected to an electrical wall socket.

18. The bridge of claim 17, wherein the data center makes a final determination about the sound.

19. The bridge of claim 1, wherein the computing device is a wall wart.

20. The bridge of claim 1, wherein the internet-facing radio and the second radio transmit radio waves for communication purposes.

21. The bridge of claim 1, wherein the non-internet device is a low power device.

22. The bridge of claim 1, wherein the bridge provides at least a partial analysis of an alarm sound received from an alarm that is in the interior of the dwelling.

23. The bridge of claim 1, wherein the bridge provides at least a partial probability analysis of an alarm sound that is in the interior of a dwelling where the bridge is located, where the probability is directed to sound of interest that is indicative of an adverse condition in the interior of the dwelling.

24. The bridge of claim 23, wherein the adverse condition is a detection of smoke.

25. The bridge of claim 23, wherein the adverse condition is a detection of an intrusion into the dwelling.

26. The bridge of claim 1, wherein the bridge is in communication with the data center.

27. The bridge of claim 26, wherein the data center includes a filter for further analysis of the adverse condition.

28. The bridge of claim 1, wherein the data center provides further analysis of the alarm sound for the adverse condition.

29. The bridge of claim 28, wherein the data center notifies the user of the alarm sound.

30. The bridge of claim 28, wherein the data center notifies the user of the alarm sound and gives the user the option to listen to a snippet of the sound.

31. The bridge of claim 28, wherein the data center first routes the sound to a manned operation center for confirmation before notifying the user.

32. The bridge of claim 28, wherein in operation the bridge makes an initial analysis but not a final analysis of the sound.

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33. The bridge of claim 1, wherein the bridge provides a bridge between the non-internet devices to the internet by communicating through a router connected to the internet.

34. The bridge of claim 1, wherein a user at the dwelling makes a final a determination relative to an interpretation of the sound. 5

35. The bridge of claim 1, wherein the bridge acts as a filter and it forwards sounds of interest to the data center for further analysis.

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